Atlantic Gold

Appendix F.7

Touquoy Integrated Water and Tailings Management Plan - Beaver Dam Gold Project - April 15, 2021

Completed for the Updated 2021 Beaver Dam Mine EIS

Stantec

TOUQUOY INTEGRATED WATER AND TAILINGS MANAGEMENT PLAN – BEAVER DAM GOLD PROJECT

FINAL REPORT

April 15, 2021

Prepared for:

Atlantic Mining NS Inc.
409 Billybell Way, Mooseland
Middle Musquodoboit, NS B0N 1X0

Prepared by:

Stantec Consulting Ltd.
845 Prospect Street
Fredericton, NB E3B 2T7

Job No.: 121619250

Sign-off Sheet

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This report was prepared by Rachel Jones, Water Resources Engineer and reviewed by Jonathan Keizer, M.Sc.E., P.Eng. If you required additional information, please do not hesitate to contact us.

Prepared by ____________________
(signature)

Rachel Jones, P.Eng.

Jonathan Keizer
2021.04.15
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Reviewed by____________________
(signature)

Jonathan Keizer, M.Sc.E., P.Eng.

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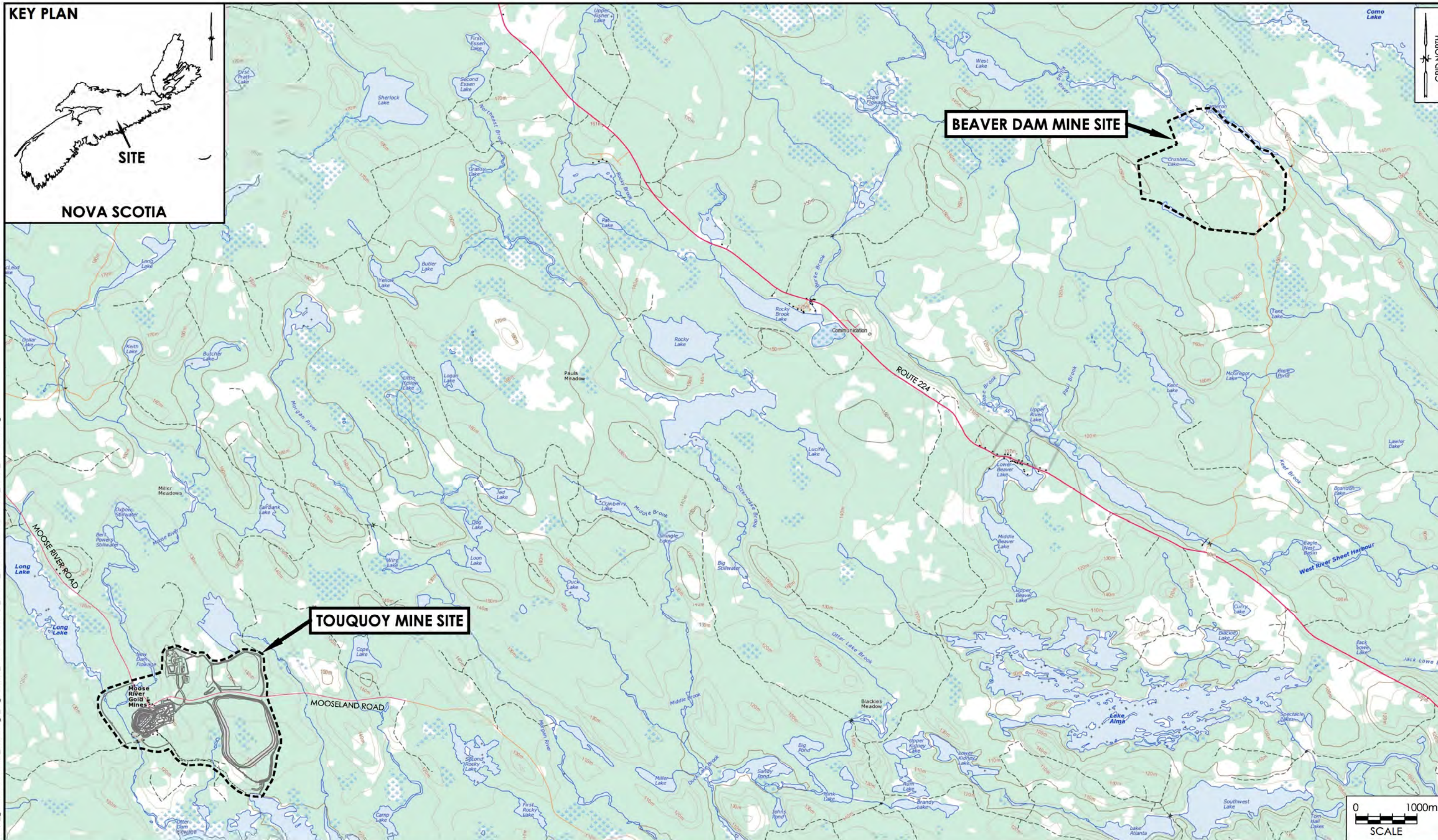
1.0 INTRODUCTION

The Beaver Dam Gold Project is a satellite deposit to the Touquoy operation with haulage of concentrate ore 57 km by road to the Touquoy Mill for processing following completion of mining at Touquoy. As part of the Project, Beaver Dam ore is processed at the existing Touquoy mill site and will extend production at Touquoy by almost 4 years. Beaver Dam ore processing commences in 2023, pending regulatory approval. Tailings generated by processing the Beaver Dam ore is deposited in the exhausted Touquoy pit.

This report covers the Beaver Dam ore processing at Touquoy and does not cover the offsite open pit mines or associated haulage. The location of the Beaver Dam mine site in relation to the existing Touquoy mine site is depicted in Figure 1.1. This report summarizes the water and tailings management plan, including Beaver Dam tailings deposition and the integrated mine site water balance, in support of the environmental impact statement screening document for the Beaver Dam Gold Project.

This report is divided into four sections:

- **Section 2.0 Operational Water Management Plan** – outlines the sources of reclaim and make up water during the processing of Beaver Dam ore at the Touquoy mill site, manage site runoff, seepage and other flow components.
- **Section 3.0 Conceptual Tailings Deposition Plan** – outlines the tailings deposition methods based on subaqueous deposition, considering seasonality.
- **Section 4.0 Water Quantity Balance** – outlines the predictions of water volume discharged to the exhausted Touquoy pit, water volume available for reclaim in the Touquoy Tailings Management Facility (TMF), required freshwater make-up from Scraggy Lake, and the timing of when water could be reclaimed from the exhausted Touquoy pit rather the Touquoy TMF.
- **Section 5.0 Water Quality Balance -** outlines the predictions of water quality in the pit lake and effluent discharge to Moose River.



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SITE LOCATION PLAN

TOUQUOY INTEGRATED WATER & TAILINGS MANAGEMENT PLAN
HALIFAX COUNTY, NOVA SCOTIA

Client: ATLANTIC MINING NS INC.

Job No.:	121619250
Scale:	1 : 60 000
Date:	17-JAN-2019
Dwn. By:	JL
App'd By:	RJ

Fig. No.: 1.1

Stantec

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2.0 OPERATIONAL WATER MANAGEMENT PLAN

2.1 EXISTING TOUQUOY OPERATION

Figure 2.1 depicts components of the operational water management plan at the Touquoy mine site, including the existing mill site, Touquoy TMF, effluent treatment plant, and the ultimate extent of the exhausted Touquoy pit. Water management at Touquoy is described in more detail in the water management plan (Stantec 2017a) and the Water Balance Report (Stantec 2016), excluding integration of the use of the exhausted Touquoy pit for tailings deposition. Figure 2.1 also illustrates the direction of flow between components, effluent discharge locations, mine component drainage areas, and locations of MDMER final discharge point(s). The MDMER final discharge point for Touquoy operations is located at SW-14 at the outlet of the Touquoy TMF polishing pond that ultimately drains to Scraggy Lake. Routine water quantity and quality monitoring is conducted to satisfy MDMER, inform water management at Touquoy, and identify project effects throughout operation as required in the Industrial Approval issued by Nova Scotia Environment.

Dewatering of the exhausted Touquoy pit to the TMF ceases at the end of Touquoy ore processing. During reclamation, the exhausted Touquoy pit naturally fills overtime with water from direct precipitation, surface runoff and seepage and is allowed to eventually spill to Moose River via a proposed spillway/conveyance channel. The spillway and conveyance channel is designed to accommodate the inflow design flood in accordance with the Canadian Dam Association (CDA) guidelines. The spillway invert is set at elevation 108 metres (m) relative to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), approximately 2 m below the lowest Touquoy pit elevation to prevent overtopping. A Final Discharge point will be located just downstream of the spillway, approximately 70 m downstream from the SW-2 monitoring station on Moose River for the Touquoy pit closure (Figure 2.2). Roadway access to the pit will be maintained following the construction of the spillway/conveyance channel.

When the Touquoy pit is exhausted of ore and the Touquoy TMF has reached its tailings storage capacity, reclamation activities will commence for the Touquoy TMF and downstream discharge facilities (i.e., the geobags, polishing pond, and constructed wetland). As part of reclamation, the TMF continues to receive surface runoff the waste rock storage area, seepage collection ditches, and direct precipitation and discharge from the TMF treated in the effluent treatment plant. Associated perimeter ditching will remain in place to capture toe seepage from the TMF and waste rock storage area until water quality meets reclamation regulatory water quality requirements as described in the reclamation plan for Touquoy (Stantec 2017b).

During closure of the existing Touquoy TMF, the existing polishing pond and wetland dams will be breached, the ponds drained, and the entire area, contoured and revegetated, retiring the final discharge point. This will result in reduced water surplus from the TMF.

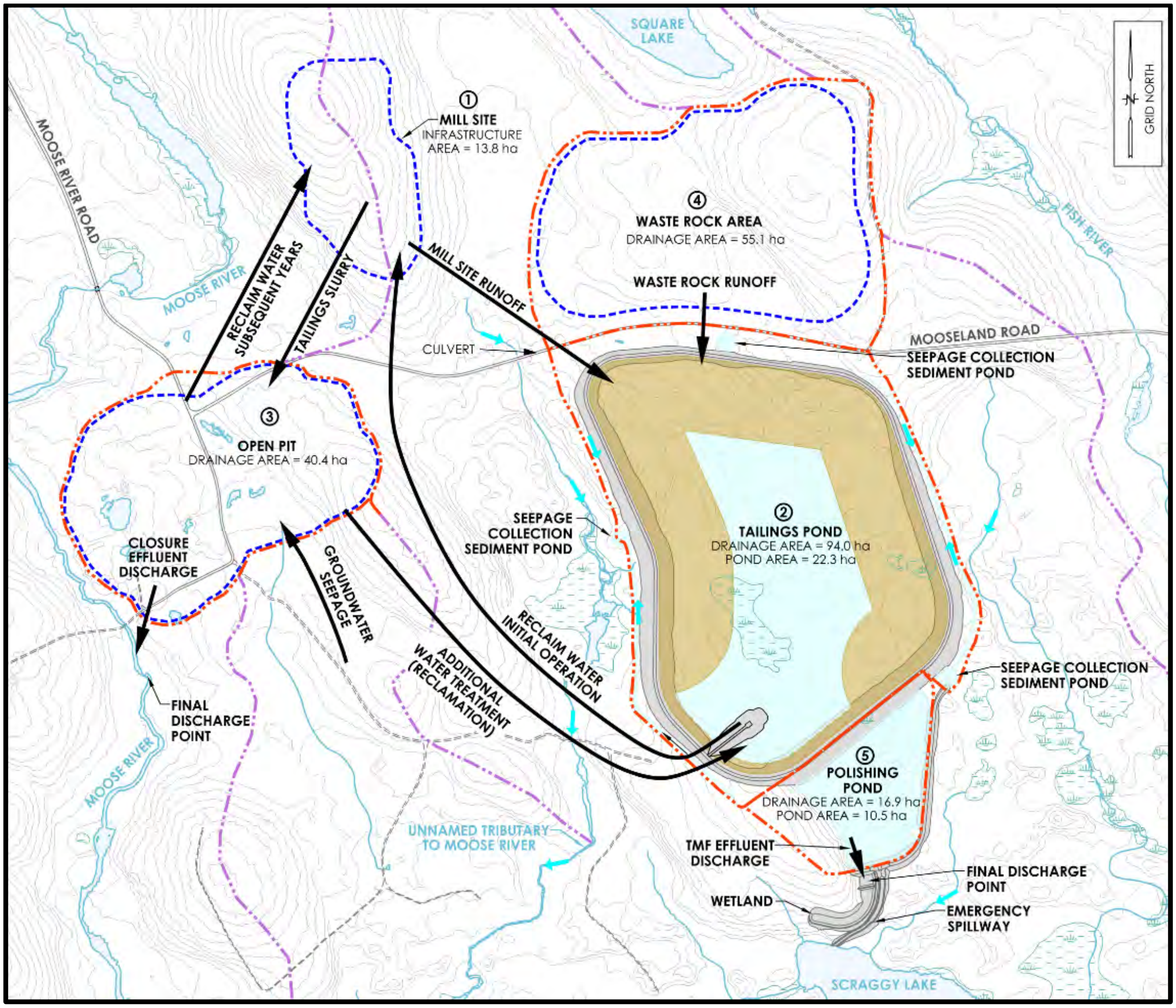


Figure 2.1 Major Mine Site Components at Touquoy

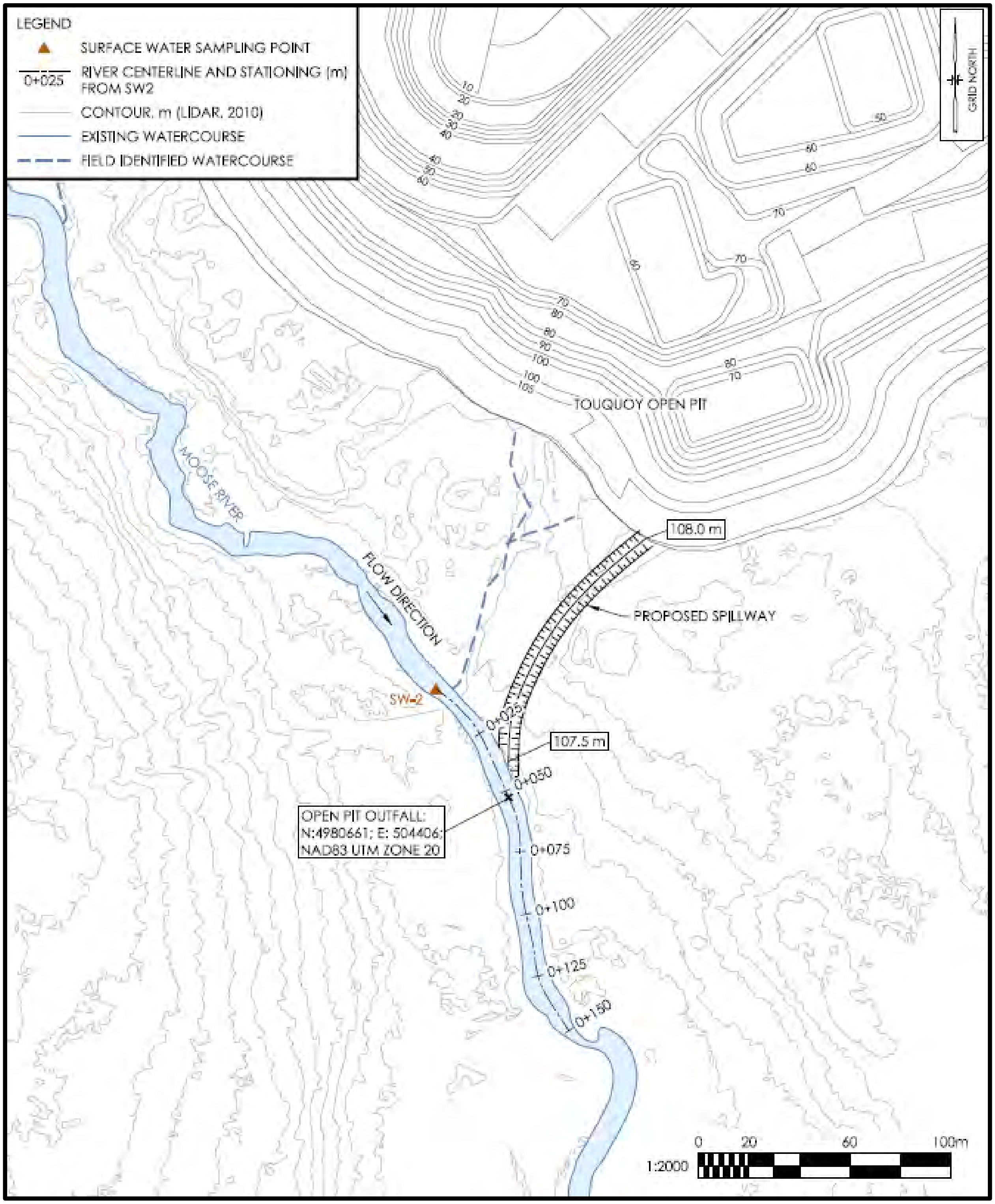


Figure 2.2 Location of Exhausted Touquoy Pit Outfall

2.2 WATER MANAGEMENT TO ACCOMMODATE BEAVER DAM ORE PROCESSING

An overview of key features of the Touquoy water management plan for the Beaver Dam Gold Project are provided in the sections below. Water management is presented by project phase (Operation, Reclamation, and Closure) as it pertains to Beaver Dam Gold Project. The operational phase of the Project corresponds to the period when Beaver Dam ore is processed at the Touquoy mill. Following ore processing, water is treated during the reclamation phase and allowed to spill from the exhausted Touquoy pit and discharge to Moose River during the closure phase.

2.2.1 Beaver Dam Project Phase – Operation

The Beaver Dam Project involves processing Beaver Dam ore at the Touquoy mill. Tailings from the processing of Beaver Dam ore are deposited into the existing Touquoy pit. Initially, water is reclaimed from the Touquoy TMF until water storage is depleted and no longer adequate to meet process water demand. After which water is reclaimed from the exhausted Touquoy pit as a closed loop. A floating barge and associated infrastructure will be installed in the pit. The barge will raise with the water and tailings elevation in the pit, decreasing pump head and associated pumping costs over time.

Delay of water reclaim from the Touquoy pit provides time for water inflows to collect in the pit as a start-up process water supply. Additional Beaver Dam ore processing start-up water supply is sourced from Scraggy Lake, subject to NSE water withdrawal approval. Freshwater make-up for the process is sourced from Scraggy Lake, as conducted under existing operations associated with processing the Touquoy ore. Additional make-up process water required in a dry year or to build a reservoir in case of a dry year will be sourced from effluent from the TMF treatment plant or Scraggy Lake, subject to NSE approval.

Water levels in the pit will slowly rise overtime, from natural runoff to the pit, direct precipitation, and tailings deposition throughout processing of Beaver Dam ore. Management of water levels in the exhausted Touquoy are maintained below the spill elevation until water in the pit lake meets MDMER discharge limits. Until such time, water in the pit is treated in the pit or pumped and treated in the existing Touquoy effluent treatment plant. Once water quality meets regulatory reclamation criteria the water level in the pit lake is allowed to spill from the exhausted Touquoy pit and discharge to Moose River during the closure phase.

Mill operation for Beaver Dam ore processing is consistent with Touquoy ore processing with respect to mill throughput, mill process flows, and tailings slurry density. Processing of Beaver Dam ore at Touquoy involves the continued use of Touquoy water management facilities, including the collection of surface runoff and toe seepage from the TMF and treatment in the effluent treatment plant and downstream discharge facilities.

2.2.2 Beaver Dam Project Phase – Reclamation

The objective of Water Management at Touquoy to accommodate Beaver Dam ore processing during reclamation is the water quality in the pit lake to meet the reclamation regulatory water quality requirements or site-specific criteria.

Similar to the Operation Phase of the Project, reclamation associated with processing of Beaver Dam ore at Touquoy involves the continued use of Touquoy water management facilities, including the collection of surface runoff and toe seepage from the TMF and treatment in the effluent treatment plant and downstream discharge facilities.

Consistent with the reclamation plan for the existing Touquoy mine, the exhausted Touquoy pit fills with water overtime and is allowed to spill through a proposed spillway/conveyance channel to Moose River. However, as the Touquoy pit will contain both water and tailings, the pit lake can be treated throughout reclamation as the pit fills. The pit lake is treated as a batch reactor with the objective of adjusting the pH to precipitate metals thus improving discharge quality. Until water quality meets discharge criteria, the water level in the pit lake is maintained at or below elevation 108 m (i.e., corresponding to the spillway elevation) thus reducing seepage to Moose River and normalizing treatment rates to the extent feasible. Surplus water in the exhausted Touquoy pit is pumped to a treatment facility until such time as water quality monitoring indicates that water quality is suitable for direct discharge to the environment.

Water management of the pit lake level maintains a minimum of 1 m water cover above the deposited tailings to both facilitate operation of the barge pump and limit the resuspension of tailings solids. The water cover depth varies over the tailings depositional period to limit resuspension of tailings. This minimum water cover is maintained at the existing Touquoy operation, without issues of resuspension of tailings particles.

The water level in the pit lake is maintained during reclamation through operation of the effluent treatment plant. The effluent treatment plant operates intermittently during non-frozen periods (April – November, inclusive) to lower the pit lake to 103 m by the end of November thus providing storage over the period when the effluent treatment plant is shut down. Assuming the existing effluent treatment rate of 300 cubic metres per hour (m^3/hr), the effluent treatment plant operates for six months to pump and treat the annual climate normal surplus of the Touquoy pit watershed of 436,000 cubic metres (m^3).

2.2.3 Beaver Dam Project Phase – Closure

Once water quality meets regulatory reclamation criteria without treatment, the exhausted Touquoy pit is prepared for closure, in accordance with the mine site closure plan. The effluent treatment plant is no longer required. Surplus water in the exhausted Touquoy pit is allowed to discharge via the proposed spillway/conveyance channel (see Figure 2.2) to Moose River, subject to meeting regulatory discharge criteria.

Similarly, treatment of the surplus water from the existing Touquoy TMF will continue at the existing effluent treatment plant until water quality meets regulatory reclamation criteria at the existing Final Discharge Point (SW-14), as outlined in the Touquoy reclamation and closure plan.

3.0 CONCEPTUAL TAILINGS DEPOSITION PLAN

This section presents a conceptual plan for subaqueous deposition of conventional tailings slurry into the exhausted Touquoy pit from Beaver Dam ore processing. The total capacity of the exhausted Touquoy pit at the proposed spillway elevation of 108.0 m is of 8.962 million cubic metres (Mm^3) is sufficient to store tailings Beaver Dam ore processing using subaqueous (i.e., in water) deposition. Considering subaqueous deposition, the exhausted Touquoy pit can accommodate the estimated total deposited volume of 6.03 Mm^3 from Beaver Dam ore processing.

Subaqueous deposition is the most pragmatic way to deposit tailings in the confined exhausted Touquoy pit. Subaerial deposition (i.e., tailings beach) like at the Touquoy TMF was not considered for the Touquoy pit. Subaerial deposition would introduce complexities in design and operation due to the conical geometry of the pit (reducing in area over the 25 m depth), use of the pit as a process water supply, and maintaining access to the water surface. As the capacity of the pit is adequate for tailings depositions, tailings slurry alternatives such as high-density tailings and paste were not considered.

Quality of reclaim water will need to meet criteria for total suspended solids, residual reagents and other parameters to limit fouling or reduced recoveries in the mill. These criteria will be refined in subsequent phases of study to determine if additional treatment of reclaim water will be required.

In general, spring, summer and fall operation is more flexible than winter (frozen) operations, and appropriate planning and mitigation is required to prevent potential issues with respect to maintaining minimum capacities during frozen conditions.

3.1 NORMAL OPERATION (SPRING, SUMMER AND FALL)

Tailings is transported to the Touquoy pit as thickened slurry via a tailings pipeline that runs from the mill to the exhausted pit. To facilitate deposition, the existing tailings slurry pipeline from the mill will be redirected from the TMF to the exhausted Touquoy pit. Secondary containment is achieved by running the main tailings pipeline in a lined ditch. The tailings will be deposited into the pit by end-of-pipe discharge, beginning in the lower areas and moving radially around the exhausted Touquoy pit. The tailings discharge pipe will be suspended in the pond by a floating barge. Initially, the pipe will likely discharge from surface at a lower bench as the bottom of the exhausted Touquoy pit has a deeper basin. Detailed procedures will be developed for tailings line relocation and corresponding plant shut downs to prevent plugging of the tailings pipeline.

Summer deposition is carried out in shallower portions of the pit in preparation for the winter. Bathymetric surveys are conducted at least once a year during the ice-free period to identify areas where tailings deposition should be concentrated and to create a tailings surface. From the tailings surface, design assumptions of tailings volume and average tailings deposited density can be checked. A check that capacity is available in deeper parts of the exhausted Touquoy pit to prepare for winter operation is conducted through routine updates of the tailings deposition plan .

The existing floating barge and associated infrastructure in the TMF is relocated to the exhausted Touquoy pit to facilitate water reclaim from the Touquoy pit. The reclaim barge will be placed in an area with the highest water depth. A floating baffle curtain will be installed around the barge should high suspended solids become an issue in processing.

Pertinent considerations and design criteria have been collated in Table 3.1. The assumptions presented in this water management plan should be updated with reported values when the final deposition plan is prepared. An average settled tailings density of 1.3 tonnes per cubic metre (t/m³) was assumed considering subaqueous tailing deposition, thus a lower average deposited tailings density than that of the Touquoy tailings pond of 1.44 t/m³ practicing sub-aerial deposition.

Table 3.1 Project Tailings Deposition Assumptions

Criteria	Value	Unit	Source
Tailings Characteristics			
Average settled tailings density	1.3	t/m³	
Slurry density (w/w) (% of tailings production (tonnes))	41	%	
Specific gravity	2.83	---	Stantec 2018a
Saturated water content (% of tailings production (tonnes))	36.1	%	Calculated parameter
Exhausted Touquoy Pit Characteristics			
Touquoy pit volume at spillway elev. (108.0 m)	8.962	Mm³	Ultimate Pit Design April 2017 (AMNS 2018)
Pit lake freezes over	December	month	
Pit lake ice melts	April	month	
Closure spillway elevation	108	m	
Minimum water depth - pump operation	**1**	**m**	
Minimum water cover - to reduce metal leaching	1	---	
Adjustment to mean tailings elev. (underwater cones)	8	m	
Assumed Freeboard Requirements of Touquoy pit	**1**	**m**	
Inflow Design Flood	143,000	m³	

Note: Blank fields indicate an estimate or assumption as part of this study

3.2 WINTER (FROZEN) OPERATION

Based on a review of climate normal temperatures, frozen conditions typically occur between January and April, although solid ice cover of the pond may occur as early as December. Subaqueous deposition employed in cold climates require mitigation strategies to continue deposition when the water surface is frozen. Bubbler systems can be installed around the discharge/reclaim barge and its pontoons to reduce ice formation. The discharge/reclaim barge will be placed over a deep portion of the pond to provide storage of tailings deposited throughout the ice-covered portion of the winter. Another option is to submerge the tailings slurry discharge line below the ice depth to discharge tailings to a single point, or over a linear array of discharge points within the pond during the winter period. It is not practical to access submerged tailings lines while the pond is frozen over.

4.0 WATER BALANCE MODEL

A preliminary water balance model was developed to simulate the overall operational water management of the Project in operation and reclamation. The water balance model was developed using Excel through multiple iteration and revisions simulating construction, commissioning, and operation of ore processing and tailings deposition at the Touquoy mine site to improve accuracy. Using the existing conditions water balance model at Touquoy, the model was extended to simulate the integrated water management of Project ore processing at Touquoy as part of a water and tailings management plan. Model inputs and outputs to the exhausted Touquoy pit accounted for groundwater inflows and seepage losses, surface runoff, direct precipitation, evaporation, process water, porewater lock up and reclaim to the Touquoy TMF and exhausted Touquoy pit. The objectives of the water balance model for the Project include to:

- Understand water management adjustments needed to accommodate the continued ore processing and tailings deposition
- Simulate the water and tailings volume in the exhausted Touquoy pit over the life of the Project
- Predict when it would be necessary to withdraw reclaim water from the Touquoy pit, as opposed to the TMF, under climate normal conditions

The model was run for the climate normal conditions in addition to the 1:100 Annual Exceedance Probability (AEP) wet conditions, and 1:100 AEP dry climate conditions (assuming groundwater inflow and storage in the Touquoy pit) for the during of operation, reclamation to closure. Only water elevation in the Touquoy pit is reported, as water management of the tailings pond is not changing from the Project. Considerations of flows in the TMF downstream facilities, such as the polishing pond and constructed wetland, were not incorporated into the model.

The model was run for the processing of Beaver Dam ore assumed to begin in November 2021. Water surplus in the existing Touquoy TMF will be reclaimed from the existing TMF for the Beaver Dam ore processing.

4.1 BASELINE HYDROLOGY

4.1.1 Climate

Project site climatic and hydrologic conditions are required for the water balance analysis. Baseline climate and hydrology conditions at the Touquoy mine site and relevant data required for water balance analysis are presented in this section.

The climate for the mine site is continental with temperature extremes moderated by the ocean. The coldest temperature recorded was −41.1 °C on January 31, 1920, at Upper Stewiacke (Environment Canada 2015c). Precipitation is well distributed throughout the year. July and August are the driest months on average.

Middle Musquodoboit climate station (ECCC Station ID 8203535), was used to characterize the climatic conditions at the mine site. This station is located approximately 20 km northwest of the mine site, and reports data collected between 1961 and 2011. As presented in Table 4.1, the climate normal precipitation is approximately 1357.7 mm and the average snowfall of 172.2 cm, based on a period of record 1981-2010 (climate normal period, Environment Canada 2015a). The extreme one day precipitation amount of 173 mm for the period of record of the selected climate station occurred in 1961. Temperatures typically drop below zero between the months of December through March each year.

Average annual lake evaporation is 515 mm for the mine site area based on average lake evaporation at the Truro climate station (Environment Canada 2015b) and corresponding monthly evaporation rates are presented in Table 4.1.

Table 4.1 Representative Climate Values for the Mine Site

Climate Normal for the 30-year period (1981-2010) at Middle Musquodoboit Climate Station													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Temperature (°C)	-6.2	-5.2	-1.3	4.4	9.9	14.8	18.5	18.4	14.2	8.5	3.5	-2.4	6.4
Rainfall (mm)	80.4	62.1	92.8	99.5	104.9	99.8	103.8	91.9	110.7	116.7	128.6	97.2	1188.3
Snowfall (cm)	49.4	41.3	31.4	9.5	0.5	0.0	0.0	0.0	0.0	0.0	8.2	31.9	172.2
Precipitation (mm)	129.8	100.5	124.2	109.0	105.4	99.8	103.8	91.9	110.7	116.7	136.8	129.1	1357.7
Snow Depth (cm)	40	67	64	22	6	1	0	0	0	0	25	28	21.1
Monthly Lake Evaporation at Truro Climate Station for 30 year period (1981-2010)													
Lake Evaporation (mm/day)	0	0	0	0	89.9	102	117.8	96.1	69	40.3	0	0	515.1

4.1.1.1 Wet and Dry Years

A frequency analysis was conducted to estimate annual precipitation for various return periods using the Middle Musquodoboit climate station data from 1961 to 2011. Annual precipitation totals for various return periods are presented in Table 4.2, including climate normal, wet and dry year climate conditions. The 100 year return period (1:100) wet and dry annual precipitation amounts are estimated to be 1,831.5 mm and 967.2 mm respectively.

Table 4.2 Annual Precipitation for Range of Return Period Precipitation Events

Return Period	Annual Precipitation (mm)[1]	
	Dry Year	Wet Year
Climate Normal (1981-2010)	1357.7	
5	1179.1	1485.5
10	1111.3	1579.7
25	1043.8	1687.6
50	1002.6	1761.7
100	967.2	1831.5

Note: [1] Based on the average of the period of record of climate station 8203535 Middle Musquodoboit

Maximum annual precipitation of 1,730 mm occurred in 1972 and approximately equal to the 1:40 year wet annual precipitation. Minimum annual precipitation of 1,073 mm occurred in 1992 and approximately equal to the 1:20 dry annual precipitation. Monthly distributions of the 1:100 year annual precipitation used in the water balance modelling were derived using the distribution trends observed in 1972 for wet years, and in 1992 for dry years.

A summary of the derived wet/dry year monthly climate conditions are presented in Table 4.3 for the 1:100 precipitation events. The mean monthly temperatures for the 1:100 wet year climate conditions are derived from monthly data observed during the driest year on record (i.e., in 1972). Similarly, the monthly temperatures for the 1:100 dry year climate conditions are derived from monthly data observed during the wettest year on record (i.e., 1992). The calculated annual precipitation was allocated by month based on the monthly distribution of the representative climate dry (1972) and wet (1992) years for the Middle Musquodoboit climate station.

Table 4.3 Wet and Dry Year Climate Values for the Mine Site

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Dry Year													
Temperature (°C)	-6.9	-6.1	-4.1	2.6	9.9	15.7	16.2	18.4	14.5	7.8	1.6	-2.6	**Average** 5.6
1:100 Precipitation (mm)	122.0	134.2	126.3	27.9	54.9	41.1	71.9	56.7	59.4	101.0	96.9	74.9	**Total** 967.2
Wet Year													
Temperature (°C)	-5.3	-7.5	-3.6	3.6	13	15.6	17.1	18	14.2	7.5	2.2	-10.7	**Average** 5.3
1:100 Precipitation (mm)	130.2	136.0	237.9	114.0	152.5	140.8	145.7	103.1	69.8	231.9	217.1	152.5	**Total** 1831.5

4.1.2 Streamflow

The Environment and Climate Change Canada (ECCC) hydrometric station at Beaverbank River Near Kinsac (Station 01DG003), located approximately 60 km southwest of the mine site, was selected to represent the streamflow characteristics at the mine site. The station has approximately 92 years of record (1922-2012) with a reported drainage area of approximately 96.9 km² (Environment Canada 2013). The station is at a similar elevation to the site and both stations are inland, each located approximately in the middle of the north and south coast.

The mean annual unit flow for the Kinsac station was calculated to be approximately 31 L/s/km². The mean annual unit flow was comparable to published mean annual flows for nearby stations (DFO 2012). The mean annual flow and the monthly minimum and maximum flows for the period of record of the station are presented in the Table 4.4 and in Figure 4.1. The mean monthly stream flows tend to peak twice a year, in spring and fall with low flow occurring in the summer months. The average runoff coefficient of 0.67 was calculated. The coefficient was based on the fraction of the mean annual flow over the total annual precipitation falling on the site for years when data overlapped from 1968 and 2009.

Two hydrological seasons can be identified in the monthly hydrograph and are described below:

- Spring-summer – period of first peak stream flows corresponding to the spring freshet which can extend from April to as late as September when the freshet falling limb hydrograph fully recedes; and
- Fall-winter – period of second peak stream flows start from October followed by the recession period through February of the next year.

Table 4.4 Monthly Mean Flow for Beaverbank River Near Kinsac Hydrometric Station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean (m^3/s)	3.82	3.07	4.34	6.01	3.44	1.66	0.91	0.91	1.13	2.35	4.21	4.39	3.02
Minimum (m^3/s)	0.679	0.151	0.752	1.9	0.524	0.177	0.004	0.004	0.0	0.02	0.311	1.49	0.50
Maximum (m^3/s)	15.0	9.57	10.2	11.4	11.4	7.95	3.89	6.55	6.58	10.1	10.8	9.76	9.43
Monthly Allocation	11%	8%	12%	17%	9%	5%	3%	3%	3%	6%	12%	12%	100%

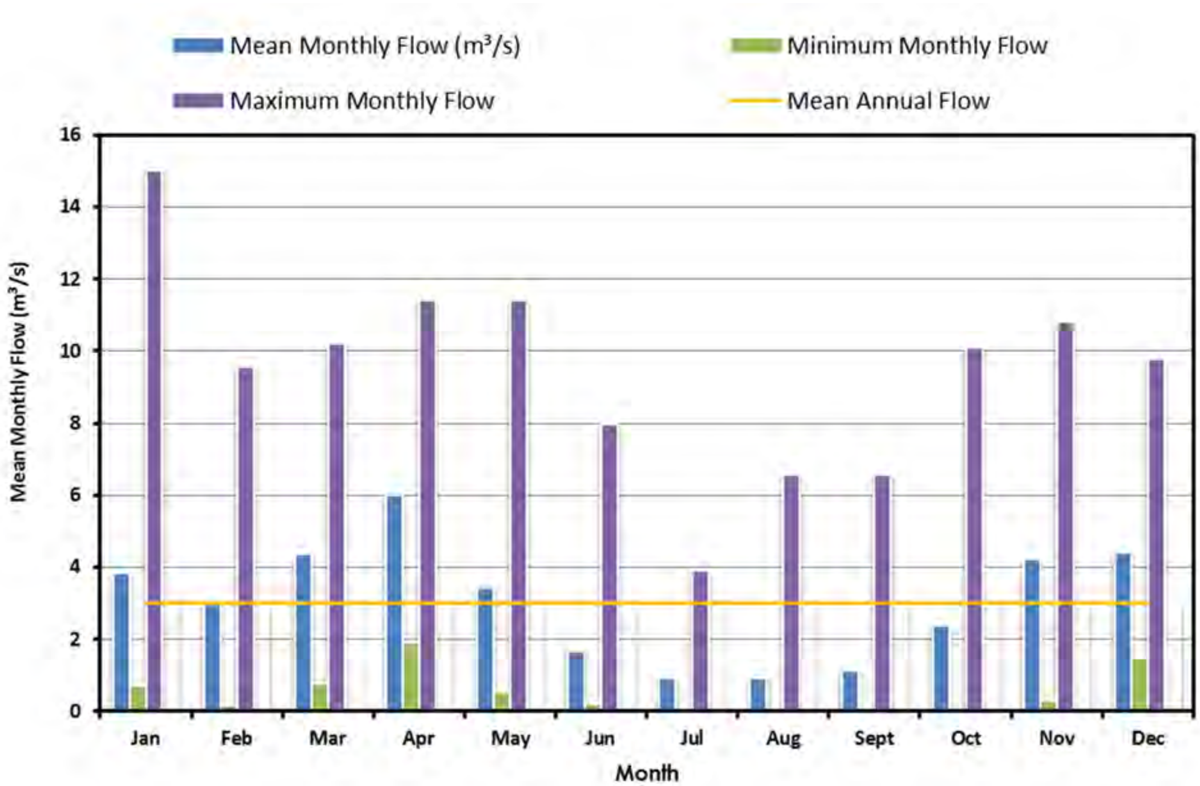


Figure 4.1 Beaverbank River Near Kinsac Hydrometric Station (Environment Canada 2013)

Streamflow data from Water Survey of Canada hydrometric stations were used to calculate the streamflow characteristics at the mine site. Three streamflow statistics were used to characterize the mine site hydrology: the mean annual flow, the instantaneous peak flow and the seven-day low flow for various return periods. Streamflow statistics were calculated using the peak instantaneous flow data for the annual populations of maxima (for flood flows) and average daily flow station data for the annual populations of minima (for drought discharge). Populations were fit to nine probability distributions; Log Pearson Type III probability distribution was determined to be the best fit to the data. The computed parameters were used to characterize the mean annual flow, flood and drought flows for the TMF and polishing pond drainage area (1.109 km²) as show in Table 4.5.

Table 4.5 Frequency Analysis for the TMF Drainage Area

	Flood Flow (m³/h)	7 Day Low Flow (m³/h)[a]
Proration Factor	**0.0114[b]**	
Return Period		
2	1800	3.6
5	2160	0.45
10	2520	0.18
25	2880	0.06
50	3240	0.03
100	3600	0.01

Note: [a] Calculated in Aquarius using a weekly average

[b] The hydrometric station drains runoff from an area greater than one order of magnitude larger than the site, as indicated by the proration factor less than 0.,; as a result the frequency analysis may over predict actual runoff conditions

4.1.3 Environmental Water Balance

The environmental water balance can be represented by the following relationship:

$$P = ET + R + I$$

where: P = precipitation;
ET = evapotranspiration;
R = surface runoff; and
I = infiltration and storage.

A spreadsheet-based monthly water balance model was used for the mine site based on the Thornthwaite and Mather method developed to estimate evapotranspiration, surface runoff, infiltration, and streamflow (Mather 1969, 1978 and 1979; Black 1996).

The spreadsheet model calculates monthly potential evapotranspiration (PET) using the Malstrom (1969) equation and is given by:

$$PET = 40.9 \times ea^*$$

$$ea^* = 0.611 \times \exp\left[(17.3T)/(T+237.3)\right]$$

where: PET = potential evapotranspiration (mm/month);
ea* = saturation vapour pressure (KPa); and
T = mean monthly temperature (°C).

Actual evapotranspiration (AET) is derived from potential evapotranspiration and soil-moisture. When P for a month is less than PET, then AET is equal to P plus the amount of soil moisture that can be withdrawn from storage in the soil. If P for a month is greater than PET, then AET is equal to PET.

Infiltration factors described by the Ontario Ministry of the Environment (OMOE 1995 and 2003) are used to determine the fraction of water surplus (excess of precipitation over evapotranspiration, P-ET) that infiltrates into the ground and the fraction that runs off to the nearby streams. The “infiltration factor” is determined from average landscape topographic slope, hydrologic soil type and vegetation cover type, and is used to determine the proportion of P-ET routed to infiltration. Infiltrated water recharges aquifers and also routes via interflow to waterbodies and watercourses. In the long term all net infiltrated water recharging aquifers is assumed to be discharged as a component of baseflow. An additional line row in the monthly water balance, estimates streamflow which integrates both overland runoff and infiltration routing back to the “stream” as groundwater discharge and interflow components of baseflow.

Although groundwater recharge and groundwater discharge may not balance within the temporal confines of a climate year, in the long-term, all water that recharges groundwater aquifers is assumed to discharge as baseflow to lakes and streams. Therefore, in the Project Study Area case, as all groundwater is assumed to flow in relatively localized groundwater watersheds which are highly correlated to the surface watersheds, all baseflow returns to the local watershed into which its source infiltration occurred. As a result of this convention, the water balance can be further simplified into ET and streamflow which includes all overland flow, interflow and groundwater discharge. It was assumed that runoff, evapotranspiration and infiltration are negligible in months with average monthly temperatures below 0°C.

The water balance model was applied to climate normal, wet and dry year climate conditions to estimate the existing condition environmental water balance over a temporal scale compatible with the Project life cycle.

The environmental water balance was modeled on a monthly basis using a spreadsheet-based monthly water balance model. The water balance model requires input of monthly precipitation, average monthly temperature, soil-moisture storage capacity and infiltration factor. The soil moisture storage capacity for the study area is assumed as 150 mm based on the geology near the open pit which indicated shallow glacial till overburden approximately 4 m in depth consisting of cobbly silt-sand deposits (Stantec 2015a).

The infiltration factor for the TMF area was calculated to be 0.6 based on a topographical factor of 0.5 for an average slope less than 0.6 m/km, a soil factor of 0.12 for clay loam/clay, and a vegetation factor of 0.02-0.05 representing shallow rooted vegetation as recommended by OMOE (2003). This implies that 40% of net infiltrated precipitation will be discharged to surface water via baseflow. It is important to note that all water recharging aquifers eventually cycles back to the surface as groundwater discharge providing baseflow to local streams and lakes. As a result, the water balance can be further simplified into precipitation, ET and streamflow.

Table 4.6, 4.7 and 4.8 show the water balance results under the climate normal, wet year and dry year conditions. Evapotranspiration accounts for approximately 34.7% of total annual precipitation under climate normal conditions at the Middle Musquodoboit Climate Station. Evapotranspiration accounts for approximately 25.6 % under the 1:100 Wet Year conditions and 42.5 % under the 1:100 Dry Year conditions. The mean annual lake evaporation for the Truro climate station is 514 mm (Environment Canada 2012); the Truro pan evaporation station is located approximately 50 km northeast of the site.

Table 4.6 Environmental Water Balance under Climate Normal Conditions (1981-2010)

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	129.8	100.5	124.2	109	105.4	99.8	103.8	91.9	110.7	116.7	136.8	129.1	1357.7
Evapo-transpiration (mm)	0	0	0	34.2	50.0	69.0	87.3	86.78	66.4	45.4	32.13	0.00	471.3
Surface Runoff (mm)	0.0	0.0	0.0	271.4	26.9	15.0	8.0	2.5	21.5	34.6	50.9	0.0	430.8
Infiltration (mm)	0.0	0.0	0.0	287.0	28.5	15.8	8.5	2.6	22.8	36.6	53.8	0.0	455.6
Streamflow (mm)	96.6	70.0	105.5	150.7	79.8	43.4	25.7	25.7	25.7	52.3	105.5	105.5	886.4

Table 4.7 Environmental Water Balance under 1:100 Wet Year Conditions

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	130.2	136.0	237.9	114.0	152.5	140.8	145.7	103.1	69.8	231.9	217.1	152.5	1831.5
Evapo-transpiration (mm)	0.00	0.0	0.0	32.4	61.4	72.6	79.9	84.6	66.4	42.5	29.3	0.0	469.1
Surface Runoff (mm)	0.0	0.0	0.0	358.8	44.3	33.1	31.9	9.0	1.6	92.1	91.3	0.0	662.1
Infiltration (mm)	0.0	0.0	0.0	379.4	46.8	35.0	33.8	9.5	1.7	97.4	96.6	0.0	700.3
Streamflow (mm)	148.5	107.6	162.1	231.6	122.6	66.8	39.5	39.5	39.5	80.4	162.1	162.1	1362.4

Table 4.8 Environmental Water Balance under 1:100 Dry Year Conditions

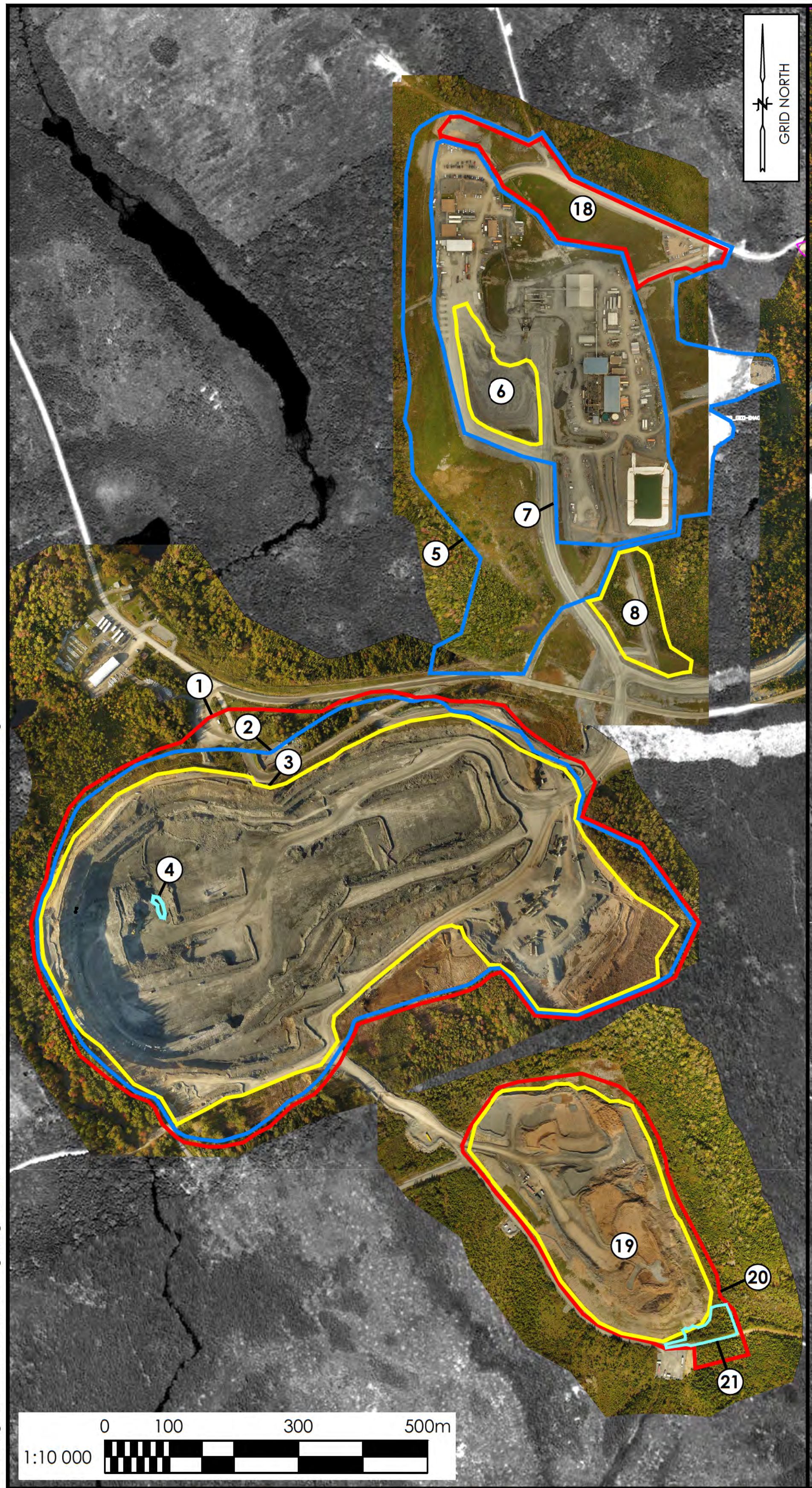
Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	122.0	134.2	126.3	27.9	54.9	41.1	71.9	56.7	59.4	101.0	96.9	74.9	967.2
Evapo-transpiration (mm)	0.0	0.0	0.0	30.1	50.0	71.1	71.9	56.7	59.4	43.3	28.1	0.0	410.6
Surface Runoff (mm)	0.0	0.0	0.0	222.3	2.4	0.0	0.0	0.0	0.0	13.4	33.5	0.0	271.6
Infiltration (mm)	0.0	0.0	0.0	235.1	2.5	0.0	0.0	0.0	0.0	14.2	35.4	0.0	287.2
Streamflow (mm)	60.9	44.1	66.5	95.0	50.3	27.4	16.2	16.2	16.2	33.0	66.5	66.5	558.8

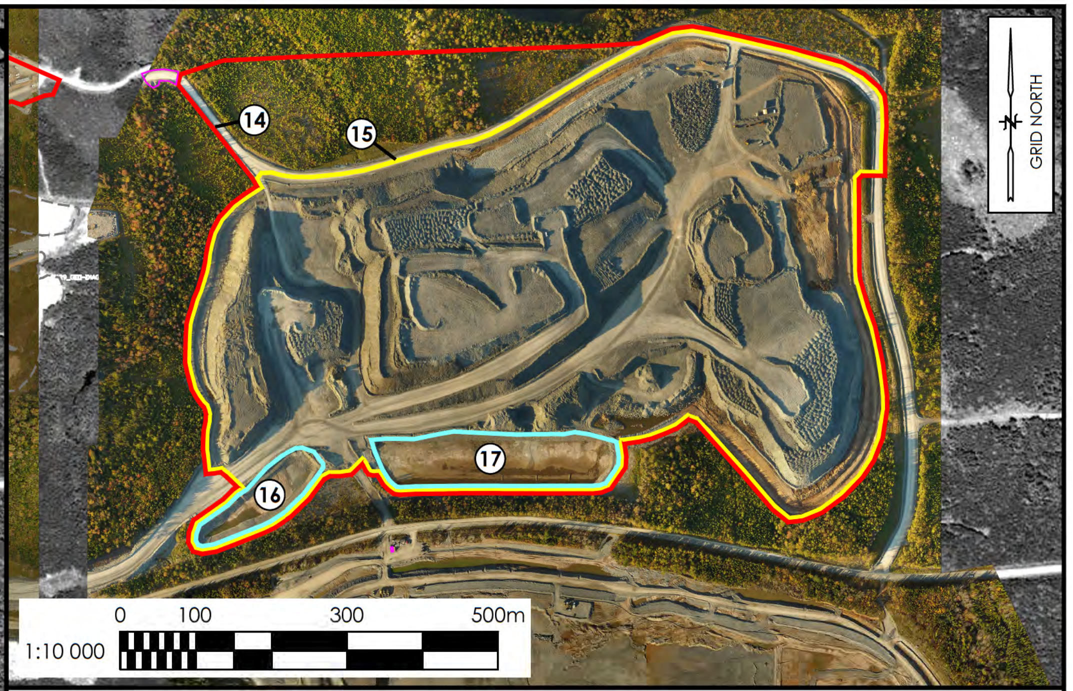
4.2 TOUQUOY TMF WATER BALANCE

The Touquoy TMF water balance was used as the basis for the water balance for the Touquoy open pit water balance for the deposition of Beaver Dam tailings. The following model inputs were used, based on the calibration of the Touquoy TMF water balance.

4.2.1 Drainage Areas

The mine site was delineated into five watersheds using the available Light Detection and Ranging (LiDAR) topography data (CRA 2010) and future mine site operational drainage conditions, as shown in Figure 4.2, and identified by area number and facility name. Each watershed was divided into land cover types comprising natural ground, prepared ground, ponds or other drainage features as listed in the table on Figure 4.2. Prepared ground is defined as paved ground, roads, industrial areas, or ground of low permeability. Drainage and sub-drainage areas may change as the mine develops.





OPEN PIT			
1	red	YEAR 5 DRAINAGE AREA	46.4 ha
2	blue	YEAR 5 INFRASTRUCTURE AREA	43.0 ha
3	yellow	EXISTING DRAINAGE AREA	35.8 ha
4	cyan	EXISTING WET AREA	0.03 ha
MILL			
5	blue	YEAR 5 INFRASTRUCTURE AREA	30.7 ha
6	yellow	EXISTING ROM PAD AREA	1.58 ha
7	blue	EXISTING AND YEAR 5 POND AREA	14.5 ha
8	yellow	EMERGENCY PUMP POND CATCHMENT AREA	1.50 ha
18	red	EXISTING AND YEAR 5 COLLECTOR POND CATCHMENT AREA	4.0 ha
SCRAGGY OVERBURDEN STOCKPILE			
19	red	YEAR 5 DRAINAGE AREA	10.7 ha
20	yellow	EXISTING DRAINAGE AREA	8.8 ha
21	cyan	2020 WET AREA	0.30 ha
TAILINGS MANAGEMENT FACILITY			
9	red	YEAR 5 DRAINAGE AREA	95.7 ha
10	yellow	EXISTING DRAINAGE AREA	103.8 ha
11	cyan	EXISTING WET AREA	34.0 ha
POLISHING POND			
12	red	EXISTING AND YEAR 5 DRAINAGE AREA	15.5 ha
13	cyan	EXISTING WET AREA	9.0 ha
WASTE ROCK AREA			
14	red	YEAR 5 DRAINAGE AREA	51.4 ha
15	yellow	EXISTING DRAINAGE AREA	43.6 ha
16	cyan	WEST POND	1.07 ha
17	cyan	EAST POND	2.46 ha

V:\1216\active\121619250\1_geotechnical\3_drawings_logs\600_TOUQUOY\SHEET FILES\16_WBAL\C19250-WBAL-RV13-FIG-4.1.dwg

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:

DATA SOURCE: DRONE IMAGERY (2019-09-06, 2019-09-28, 2019-09-30, 2019-10-01 & 2019-10-22) PROVIDED BY ATLANTIC MINING NS INC, BING IMAGERY © 2019 DIGITALGLOBE.

WATER BALANCE DRAINAGE AREAS

TOUQUOY MINE TAILINGS MANAGEMENT FACILITY

HALIFAX COUNTY, NOVA SCOTIA

Client: ATLANTIC MINING NS INC

Job No.:	121619250
Scale:	AS SHOWN
Date:	2020 02 27
Dwn. By:	JL
App'd By:	RJ

Fig. No.: 4.2

Stantec

4.2.2 Runoff Coefficients

Model input runoff coefficients were adjusted based on the operational responses for the Touquoy TMF to match measured parameters for natural ground, prepared ground and pile/pit/dam or beach surfaces. As summarized in Table 4.9, the runoff coefficient of the waste rock pile to match measured pump volumes to the TMF was 0.43. A higher value of 0.5 was forecasted for the 1:100 year climate condition to account for the increase toe drainage below the pile overtime from wetting.

Table 4.9 Run-off Coefficients at the Touquoy Mine Site

Facility	Natural Ground	Prepared Ground	Pile/Pit/Dam/ Beach
Mill Site	0.67	0.85	0.9
Open Pit	-	0.75	0.6
Waste Rock and Overburden Piles	-	-	0.43 (dry/climate normal), 0.5 (wet)
TMF	0.75	0.85	0.9/0.92*
Polishing Pond	0.67	0.85	0.9
Scraggy Overburden Stockpile	-	0.85	0.9
Note: * Run-off Coefficient of TMF Dam and wet tailings beach/dry tailings beach			

4.2.3 TMF WATER INFLOW AND OUTFLOW VOLUME FORECAST

The TMF is the receptor for process flows from the mill in addition to pit dewatering, waste rock area drainage, seepage collection ponds, and miscellaneous inputs. Figure 4.3 presents the forecasted water volumes pumped/piped in and out of the TMF based on the 2020 calibrated water balance (Stantec 2020). Inflows include water pumped from the pit sump pond, waste rock area collection pond(s), and seepage collection ponds. Outflows include the volume treated in the existing effluent treatment plant and process water from the TMF, presented as the net of tailings slurry water volume in the TMF, and the water lock-up and process water demand. For comparison to direct flows in the TMF, the net precipitation (i.e., precipitation less evaporation and seepage losses) is presented in the Figure 4.3. As noted in the figure, the sum of inflows from the Touquoy pit and waste rock collection pond dewatering is comparable to the net precipitation in the TMF.

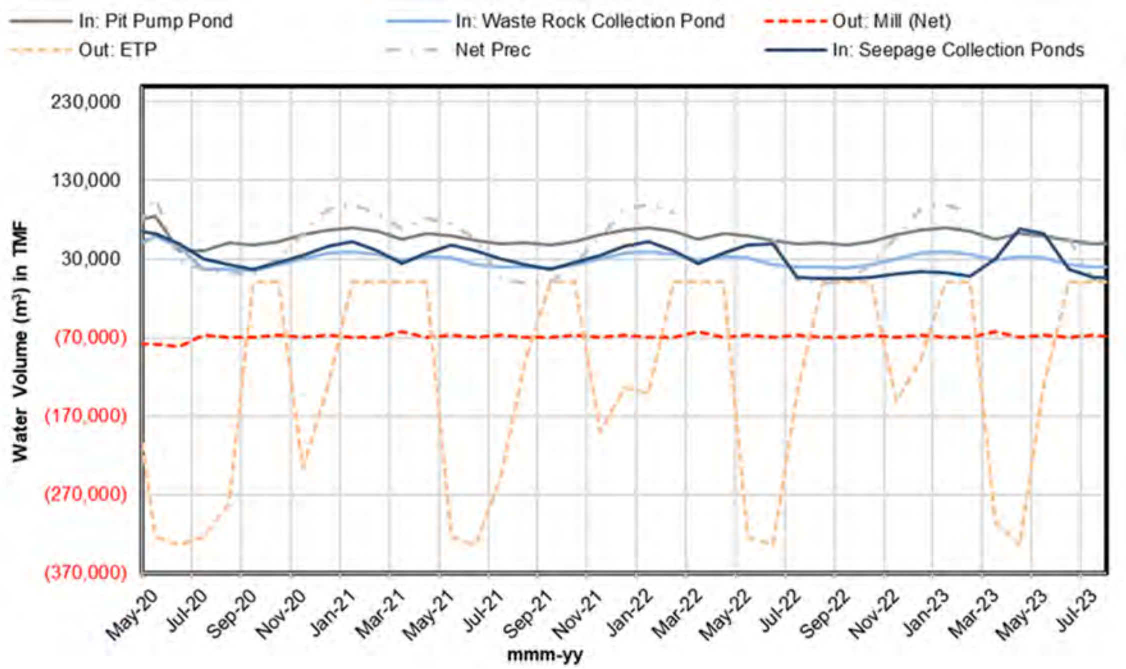


Figure 4.3 Water Volume In and Out of TMF – Climate Normal Condition

4.3 EXISTING CONDITIONS AND ASSUMPTIONS FOR TOUQUOY OPEN PIT TAILINGS MODEL

Water balance assumptions for the deposition of tailings from the Beaver Dam Project in the Touquoy Open Pit are listed below.

Mill Process Flows

- Start-up process water supply in Touquoy pit will be sourced from the following:
  - Reclaiming water from the TMF for the first five months of operation, assuming start-up in spring
  - To offset anticipated start up reclaim deficit and build deposited tailings water cover, increase freshwater make-up from Scraggy Lake of 15,862 m³/month to the maximum monthly permitted rate of 21,900 m³/month for the first 7 months of reclaim in the Touquoy pit
  - Stop pit dewatering five months prior to start-up of tailings deposition in the exhausted Touquoy pit. This will result in water collected in the pit for use as process supply in start-up
  - Withdraw additional start-up volume from Scraggy Lake based on climate normal conditions (subject to a permitted water withdrawal approval from NSE)
- Process freshwater make-up water requirements of approximately 5.8% of production will be sourced from Scraggy Lake as per the existing NSE approval for Touquoy ore processing or other sources as directed in the NSE approval for Beaver Dam; consistent with the Touquoy operations, following the initial start-up volume. Should additional process make-up water be required in a water reclaim deficit scenario, the Scraggy Lake supply will be supplemented with treated effluent from the existing Touquoy mine polishing pond
- Average tailings water discharged with tailings slurry of 8,758 m³/d

- Average reclaim water to mill of 8,355 m^3/d
- Moisture going into mill of 2.5% of tailings production (t) for Beaver Dam
- Water lost to evaporation and spillage of 3.0% of tailings production (t)

TMF (Drainage area of 94 ha)

- TMF at high normal operating water level at commencement of tailings deposition in the exhausted Touquoy pit (approximately 1 Mm^3) to store water available for reclaim
- TMF at ultimate spillway design elevation 128.5 m with a dam crest elevation of 130.0 m CGVD2013 assuming 7.36 million cubic meters (Mm^3) of tailings storage volume and 1.30 Mm^3 of water storage below the spillway invert elevation of 128.5 m
- Minimum inactive storage in the tailings pond is 635,500 m^3 in non-frozen months, and 825,500 m^3 in frozen months
- Surplus water discharge to the effluent treatment plant at a maximum rate of 300 m^3/hr
- Seepage from the TMF at 1,336 m^3/d, of that 200 m^3/d is captured in polishing pond and 736 m^3/d re-circulated to the TMF in non-frozen months and the remainder bypasses to groundwater
- Accepts inputs from undiverted catchments (waste rock storage area and mill pond runoff)

Waste Rock Storage Area (Drainage area of 55.1 ha)

- The waste rock storage area is not expanding over the life of Beaver Dam project
- The runoff coefficient at the commencement of the Project is estimated at 28%. However, the runoff coefficient of the waste rock storage area is expected to increase to 70% over 15 years as the waste rock storage area starts to wet and the transmission of infiltration and recharge through the pile improves over time
- Runoff coefficient increases from 5 to 27% by the end of the Touquoy operation (e.g., from existing conditions in Touquoy operation to a model result from a reference waste rock site)

Exhausted Touquoy Pit (Drainage area of 40.4 ha)

- Touquoy pit receives 5 months of runoff (associated to remaining volume in Touquoy TMF) upon commencement of Beaver Dam ore processing amounting to a water volume of 273,000 m^3 with a bottom elevation from -25.0 m to 11.2 m CGVD2013
- Touquoy pit geometry as per the ultimate pit design of April 2017 at ultimate stage
- Model represents climate normal, 1:100 AEP and 1:100 AEP climate conditions, characterized by Environment Canada’s Middle Musquodoboit climate station (Station ID 8203535)
- Total storage capacity at the overflow elevation 108 m CGVD2013 of 8.962 $Mm^{3.}$
- Natural filling of the Touquoy pit over time to create a pit lake water cover over of the deposited tailings
- The pit lake amounts to a minimum of approximately 15 m of water cover above the tailings, assuming the spillway invert elevation of 108 m CGVD2013
- Net groundwater inflow to the pit consistent at 768 m^3/day but decreasing to 373 m^3/d as the water elevation rises to a maximum of 108 m CGVD2013 (Stantec 2021a), as illustrated on Figure 4.4
- An emergency spillway in the Touquoy pit with invert of 108 m, a Touquoy pit crest elevation of 109.5 m to prevent overtopping and a conveyance channel to Moose River
- The elevation storage relationship for the exhausted Touquoy pit is illustrated in Figure 4.5, based on the 2017 mine plan

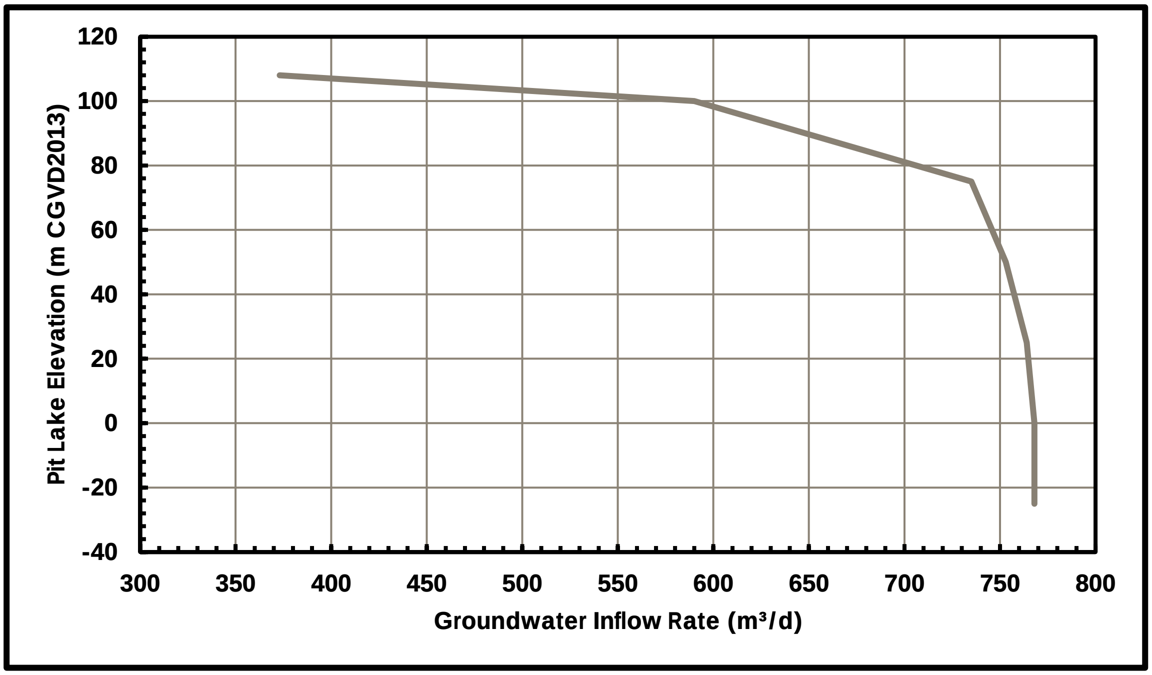


Figure 4.4 Groundwater Inflow Rates to Pit Based on Water Elevation in Touquoy Pit

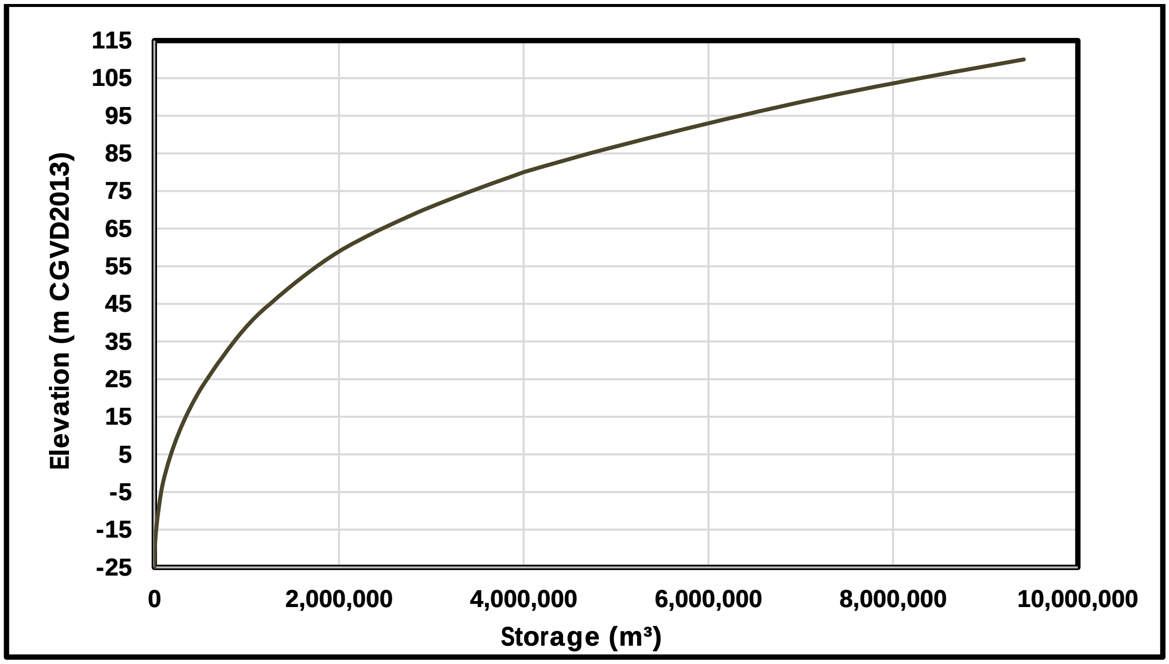


Figure 4.5 Elevation Storage Relationship in the Exhausted Touquoy Pit

4.4 MODEL RESULTS

The water balance model predicted the amount of water and tailings stored in the pit over the simulation period for Beaver Dam ore processing. Tailings is deposited in the exhausted Touquoy pit for a total of 41 months including a five-month pre-processing period to allow the water level in the open pit to reach an elevation in the pit of 93.2 m CGVD2013. As originally planned in the approved Touquoy Gold Mine Project Reclamation Plan (Stantec 2017b), the inflow of groundwater, surface runoff and precipitation into the pit will naturally create a lake upon closure of the site. The water balance model simulated that it would take an additional 100 months or a total of 141 months from commencement of tailings deposition in the exhausted Touquoy pit to fill the pit to the spillway invert elevation. Figures 4.6 and 4.7 illustrate the predicted water and tailings elevation and storage volume in the exhausted Touquoy pit, respectively.

Based on results of the water balance model, process water can be reclaimed from the TMF for the duration of Beaver Dam ore processing for the modelled climatic conditions. Adequate water supply is available for start-up as the process water demand is low in comparison to Touquoy processing.

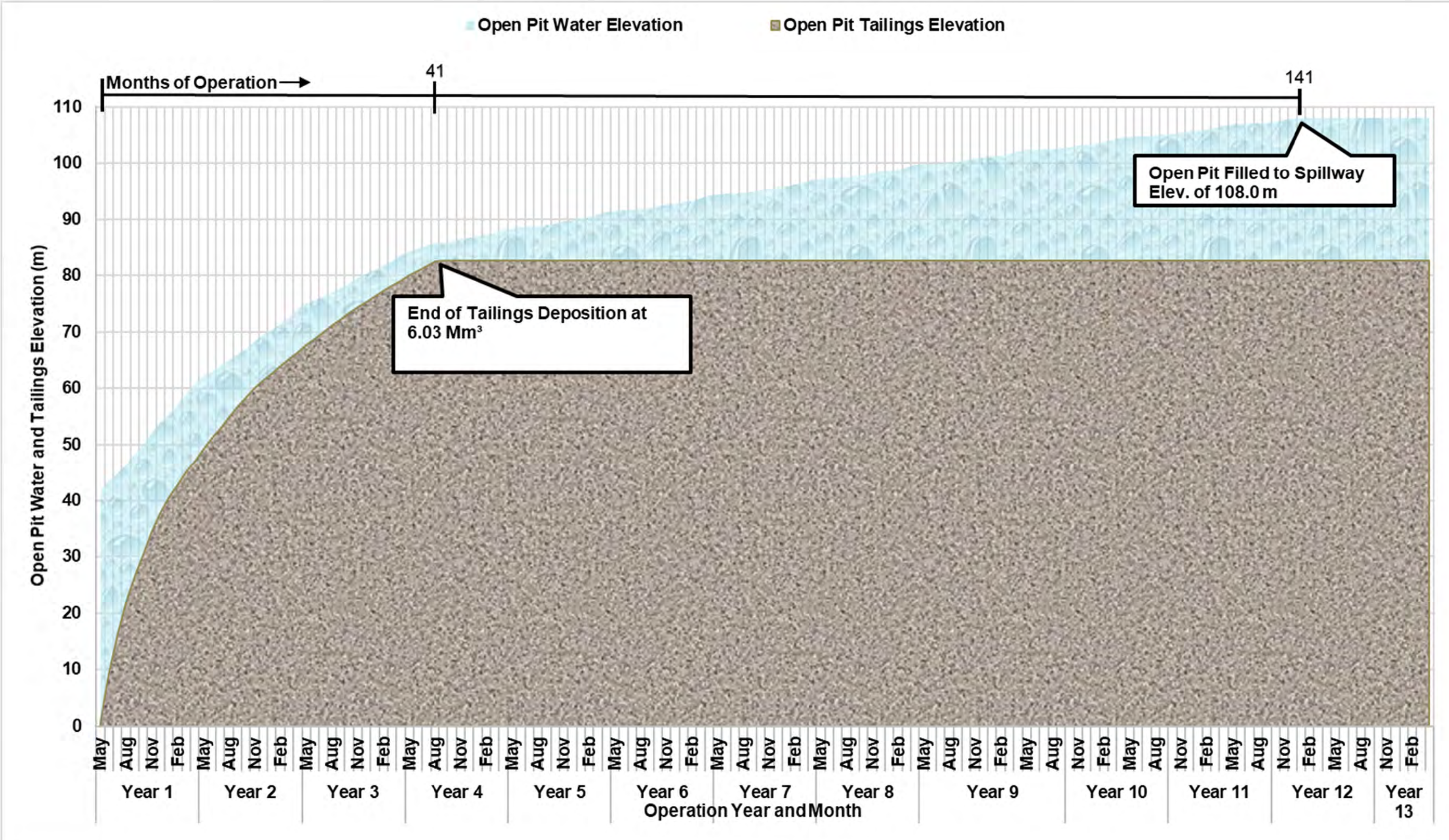


Figure 4.6 Tailings and Water Elevation in the Exhausted Touquoy Pit

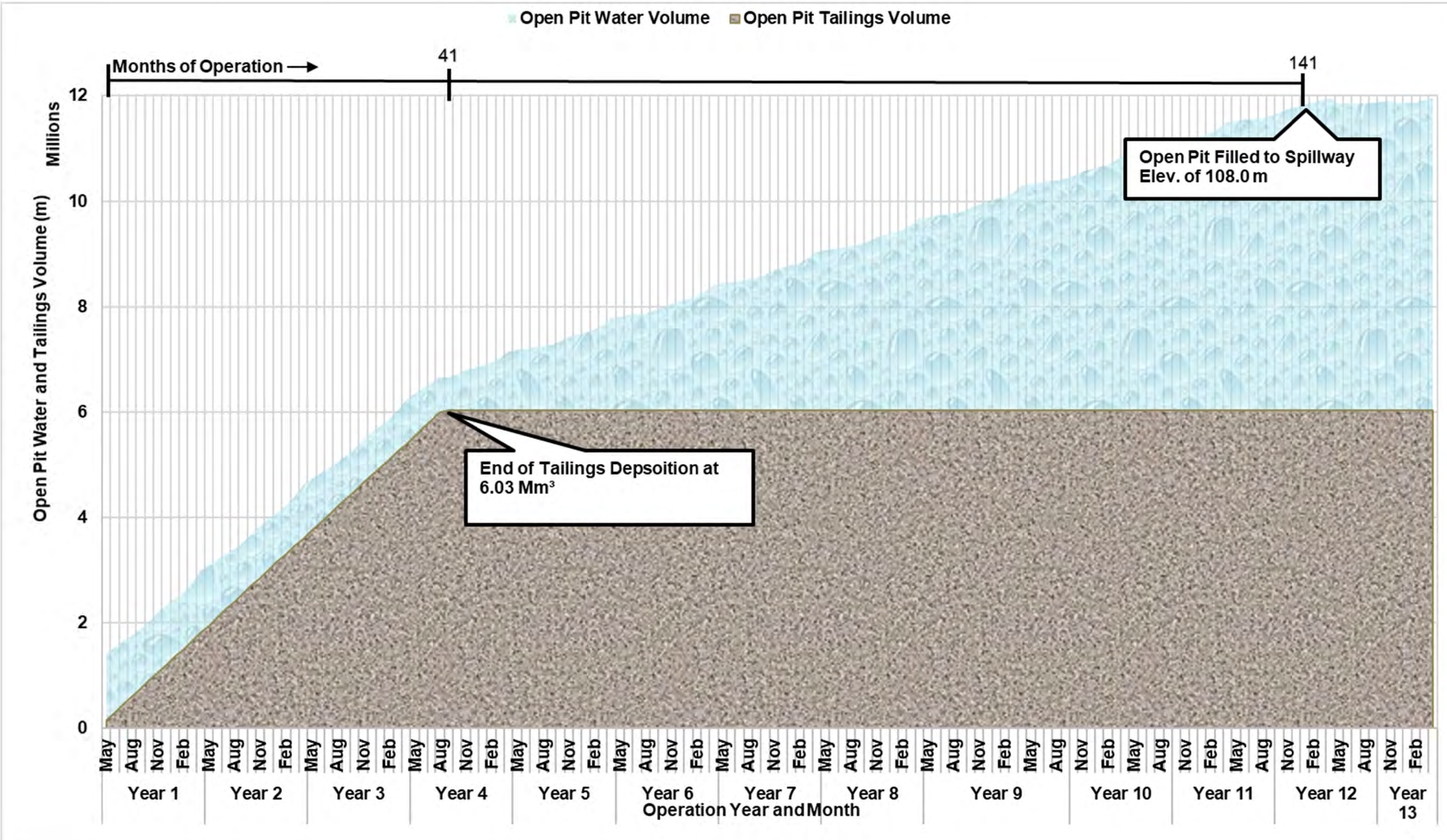


Figure 4.7 Tailings and Water Storage Volume in the Exhausted Touquoy Pit

The average monthly inflows and outflows from the open pit once the pit is full are summarized on Table 4.10.

Table 4.10 Average Monthly Inflows and Outflows (m^3/month) to Filled Touquoy Open Pit

Month	Total Runoff to Open Pit	Groundwater Inflow	Evaporation	Outflow
January	19,748	19,654	0	-39,402
February	25,022	17,911	0	-42,933
March	62,773	19,654	0	-82,427
April	107,075	19,020	0	-126,095
May	42,838	19,654	-36,251	-26,241
June	40,562	19,020	-41,130	-18,452
July	42,188	19,654	-47,502	-14,340
August	37,351	19,654	-38,751	-18,254
September	44,992	19,020	-27,824	-36,189
October	47,431	19,654	-16,251	-50,835
November	55,600	19,020	0	-74,620
December	26,235	19,654	0	-45,889

5.0 WATER QUALITY MODEL

Deposition of tailings in the exhausted Touquoy pit will alter water quality in the pit compared to filling of the pit as per the Touquoy reclamation plan (Stantec 2017b). The monthly water quality model for the exhausted Touquoy pit was developed using Excel to simulate the overall water quality of metal parameters, cyanide, and nitrogen species (including ammonia, nitrate, and nitrite) during operation, reclamation, and closure of the Project. This model was developed from the water balance spreadsheet for the open pit, using inputs from the existing and calibrated water balance for the Touquoy TMF. The objectives of the Touquoy water quality model are to predict future water quality and inform water treatment required prior to the pit lake effluent discharge to Moose River, and the water quality of effluent discharge to Moose River at aquatic monitoring stations. The environmental effects of predicted discharge water quality in Moose River are assessed.

5.1 GEOCHEMICAL SOURCE TERMS

Water quality modelling considered the pore water quality in the tailings and the pit floor/ walls, the dilution from surface runoff, direct precipitation in the exhausted Touquoy pit and the water quality of the mixture based on the geochemistry of the individual water quality parameters. As discussed in the source terms memo (Lorax 2018), geochemical source term predictions of pore water quality of pit walls/floor were derived from upscaling of kinetic tests and Touquoy monitoring data. The geochemical model used to develop the source terms (Lorax 2018) simulated the oxidation and reduction reactions to understand the water quality of the mixed pit lake quality based on the geochemistry of the individual water quality parameters during operation and reclamation. The kinetic testing and Touquoy monitoring data were considered representative for the Project as the ore bodies are from the same geologic formation as the Touquoy ore with similar marker parameter content.

As presented by Lorax (2018), geochemical source term predictions of pore water quality of pit walls/floor had elevated metal (e.g., arsenic, cobalt, copper), ammonia, nitrate and cyanide concentrations thus reducing pit lake water quality at the time of discharge.

Using the Touquoy TMF as a site analogue for saturation indices (Lorax 2018), solubility caps were predicted for iron (0.10 mg/L at end of mine and 0.039 mg/L at closure) and aluminum (0.178 mg/L at end of mine and 0.057 mg/L at closure). As recommended by Lorax (2018), a degradation rate for ammonia of $y = -0.0134x^2 + 0.4915x + 0.0676$ was applied, where x is the ammonia concentration in a given year. The degradation rate for ammonia was capped at 4.57 mg/L/yr for ammonia concentrations of 18.35 mg/L or above. Degraded ammonia was converted to nitrate and nitrite in operation and reclamation, at ratios provided by Lorax. During operation, a higher proportion of nitrite was predicted due to competing oxygen-consuming mechanisms where 25% as NO_3 and 75% as NO_2 (Lorax 2018). Within approximately 3 years following completion of tailings deposition, most of the nitrite was estimated to oxidize to nitrate with 98% as NO_3 and 2% as NO_2.

5.2 MODEL INPUTS AND ASSUMPTIONS

The water quality model combined the quality of the source terms with the water balance model flows and groundwater interaction to predict monthly discharge water quality over 50 years beginning at the start of discharge into the exhausted Touquoy pit dis, simulating steady state conditions for all source terms provided by Lorax.

As described in the previous water balance section, inputs to the pit include the tailings and water slurry deposition, direct precipitation and surface water runoff. These flows have been modelled for a climate normal scenario over 50 years.

Based on results of the groundwater flow model (Stantec 2021a), the Touquoy pit acts as a sink (i.e., gaining groundwater to the Touquoy pit) until the groundwater level reaches the shallow weathered bedrock layer. The interaction between the Touquoy pit lake and Moose River is limited to groundwater flow from Moose River to the pit during this period. Therefore, no water quality effects to Moose River are predicted during this period. When the pit lake level rises to the spillway elevation of 108 m, the groundwater flow gradients allow for seepage from the Touquoy pit to migrate towards the Moose River as baseflow at a rate of approximately 258 m^3/d. The flow rate in Moose River in April is 125 times this rate, and therefore represents a dilution ratio of approximately 125.

The water quality model predicts the effluent discharge quality from the Touquoy pit during reclamation and closure. Effluent discharge water quality from the pit lake to Moose River is required to meet MDMER discharge limits. Therefore, it was assumed that any effluent quality for any parameter that exceeds the MDMER limits will be treated to meet the MDMER limits. Discharge from the Touquoy pit is not anticipated until after 2021, therefore the MDMER discharge limits for an existing mine after June 1, 2021 were used as minimum treatment criteria for effluent discharges to Moose River. An assimilative capacity study of Moose River (Stantec 2021b) was completed to simulate the mixed water quality at the future MDMER biological monitoring stations located at 100 m, 200 m, and 1000 m downstream of the effluent discharge point.

5.2.1 Water Treatment

Similar to Touquoy ore processing, the tailings slurry from the processed ore will be subject to cyanide destruction at the process plant before flowing to the exhausted Touquoy pit. Based on water quality monitoring results at Touquoy for existing operation, cyanide destruction to cyanate is 99.5% effective (Lorax 2018). Cyanate readily complexes with metals and can precipitate under increased pH conditions. The majority of the residual cyanide reagent introduced to the tailings during ore processing will be degraded and hydrolyzed to carbon dioxide and ammonium during storage in the tailings pond. Similarly, this will be expected to occur for the Beaver Dam tailings being stored in the Touquoy pit. Potential failures related to cyanide recovery and proposed Touquoy pit disposal will be addressed in updates to the existing Touquoy groundwater contingency plan (Stantec 2019a), as required in the Industrial Approval for the Touquoy mine site.

An effluent treatment plant is planned to be located at the Touquoy open pit spillway to treat the pit lake water until MDMER discharge limits are met. The water quality of the pit lake will be monitored during the pit filling and as the pit level approaches the spillway elevation. The water quality will be compared to the MDMER discharge limits and will be treated as required to meet these limits and any additional regulatory closure criteria or site-specific guidelines. The MDMER discharge limits will decrease from the existing limits to those presented in Table 5.1 effective June 1, 2021. The discharge from the Touquoy mine site is anticipated to occur after this period, and therefore the lower MDMER limits for an existing mine will apply.

Table 5.1 Schedule 4 Limits of the Metal and Diamond Mining Effluent Regulations

Deleterious Substance	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	0.30 mg/L	0.45 mg/L	0.6 mg/L
Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
Cyanide	0.5 mg/L	0.75 mg/L	1.00 mg/L
Lead	0.10 mg/L	0.15 mg/L	0.20 mg/L
Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
Total Suspended Solids	15.00 mg/L	22.50 mg/L	30.00 mg/L
Radium 226	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L
Un-Ionized Ammonia	0.50 mg/L (as nitrogen)	Not applicable	1.00 mg/L (as nitrogen)

Proposed water treatment strategies include:

- Initial treatment of the pit as a batch reactor with the objective of adjusting the pH to precipitate metals to improve water quality in the pit lake as the pit is filling. As an additional benefit of the slow filling of the pit over time, the residence time and exposure to sunlight will increase, thus enhancing the natural UV degradation of cyanide and improving water quality in the pit lake.
- Should water treatment still be necessary, effluent from the pit will be pumped for treatment to the existing effluent treatment plant and discharged to the downstream polishing pond facilities and Scraggy lake receiving environment. Once water quality meets discharge criteria (i.e., representing closure conditions), surplus water in the pit will spill to a channel and discharge to Moose River. Discharge water quality will continue to be monitored against discharge criteria to identify if the pit should continue to be pumped and treated at the Touquoy effluent treatment plant.
- Pump and treat water in the Touquoy pit opportunistically, as the pit is filling and capacity is available in the existing effluent treatment plant.

5.3 MODEL RESULTS

The water quality model predicted an exceedance of the MDMER discharge limits. In January of Year 12 at the commencement of discharge from the Touquoy pit when the pit lake is simulated to reach the spillway elevation, the water quality model predicted elevated concentrations of arsenic and nitrite as summarized in Table 5.2 not considering planned water treatment. Results of the water quality model in the exhausted Touquoy pit over time for metals, ammonia, and cyanide parameters are presented in Appendix A, not considering planned water treatment. These figures show the water quality trend over time and the outflow to Moose River.

Table 5.2 Predicted Water Quality Concentrations to Moose River, Not Considering Water Treatment

Parameter	Effluent Discharge Concentration (mg/L) in Year 13	Groundwater Seepage Concentration (mg/L) in Year 50	Schedule 4 Limits MDMER Monthly Mean Concentration (mg/L)
(SO_4) Sulphate	195	1.3×10^{-3}	
(Al) Aluminum	0.04	6.6×10^{-8}	
(As) Arsenic	**0.689**	4.3×10^{-6}	0.30
(Ca) Calcium	60.3	1.2×10^{-4}	
(Cd) Cadmium	0.000009	2.8×10^{-11}	
(Co) Cobalt	0.051	3.7×10^{-8}	
(Cr) Chromium	0.00038	2.8×10^{-10}	
(Cu) Copper	0.028	1.3×10^{-8}	0.30
(Fe) Iron	0.035	4.6×10^{-8}	
(Hg) Mercury	0.000022	7.1×10^{-12}	
(Mg) Magnesium	6.3	2.1×10^{-5}	
(Mn) Manganese	0.127	5.2×10^{-7}	
(Mo) Molybdenum	0.008	8.5×10^{-8}	
(Ni) Nickel	0.015	9.7×10^{-9}	0.50
(Pb) Lead	0.00024	3.5×10^{-11}	0.10
(Se) Selenium	0.00066	2.7×10^{-10}	

Table 5.2 Predicted Water Quality Concentrations to Moose River, Not Considering Water Treatment

Parameter	Effluent Discharge Concentration (mg/L) in Year 13	Groundwater Seepage Concentration (mg/L) in Year 50	Schedule 4 Limits MDMER Monthly Mean Concentration (mg/L)
(Ag) Silver	0.00003	1.6×10^{-11}	
(U) Uranium	0.004	4×10^{-9}	
(Zn) Zinc	0.0023	3.2×10^{-9}	0.5
(WAD CN) Weak Acid Dissociable Cyanide	0.096	1.5×10^{-8}	0.5
(Total CN) Total Cyanide	0.274	8.0×10^{-9}	
(NO_3) Nitrate (as N)	4.57	1.4×10^{-7}	
(NO_2) Nitrite (as N)	1.16	8.5×10^{-8}	
(NH_3) Ammonia	0.23	1.8×10^{-7}	0.50 (Unionized)

Note: **Bold numbers** indicates an exceedance of MDMER discharge limit

The pit lake is simulated to take approximately 12 years to fill from commencement of depositing tailings in the exhausted pit. The water quality in the pit is predicted to initially exceed the MDMER discharge limits prior to discharge. The final water treatment design will be fully developed during operation and pit filling. The water quality is predicted to improve with time, and is predicted to no longer require treatment to meet MDMER discharge limits after approximately 19 years from commencement of depositing tailings in the exhausted pit.

6.0 MODEL SENSITIVITY AND LIMITATIONS

Results of the water balance and quality model are based on information available at the time of the study, as sections above. It is recommended that the existing conditions and assumptions be updated as information becomes available, such as further developed reclamation plan, updates of the water balance/water management plan, updates to the mine plan, testing to predict settled tailings density, and the results of operational monitoring.

The 1:100 AEP wet and the 1:100 AEP dry climate statistics are used to provide an upper and lower bound of predicted climate normal conditions. Assuming the model assumptions reflect future conditions, water levels in the TMF and exhausted Touquoy pit during the 77 months of processing of Beaver Dam ore, should fall within these bounds. Stochastic combinations of wet and dry years were not modelled.

Model sensitivity to predicted Touquoy pit groundwater inflows were conducted by adjusting the groundwater contribution of 768 m^3/d associated to a pit water elevation of -25.0 m (CGVD2013) to the groundwater contribution filled with water to elevation 108.0 m (CGVD2013) of 373 m^3/d. This change would delay the timing of when the process water reclaim is relocated from the TMF to the exhausted Touquoy pit by 1 day.

The variation in the initial pond water volume between low and high operating levels in the TMF on the available water reclaim at time of commencement of tailings deposition in the exhausted Touquoy pit was modelled. Should the pond at the time of start-up be at a low operating level opposed to a high operating level, the relocation of process water reclaim from the TMF to the exhausted Touquoy pit would be initiated 3 months after start-up, approximately 2 months earlier than if the pond is at a high operating level at start-up. Under this scenario, additional start-up water supplied by Scraggy lake is required.

Sensitivity on the deposited tailings density in the exhausted Touquoy pit was simulated. The average deposited tailings density of 1.3 t/m^3 is expected, with a lower tailings density at start-up and a higher density as tailings are deposited in the exhausted Touquoy pit due to the consolidation of the tailings from the tailings and water mass. Should we consider the lower tailings density in the first year from 1.3 t/m^3 to 1.2 t/m^3, this results in approximately 13,000 m^3/month of additional pore water lock-up, reducing the water available for reclaim during start-up.

7.0 SUMMARY & RECOMMENDATIONS

7.1 WATER MANAGEMENT

Water management plant at Touquoy for the Beaver Dam ore processing considered the existing process water requirements, existing water management infrastructure, the water inventory at the mine site, the available freshwater sources, and effluent water quality. Consistent with existing water management at the site, the TMF continues to collect direct precipitation and runoff from the tailings pond and the waste rock storage and perimeter toe seepage collection. Tailings slurry is discharged to the exhausted Touquoy pit upon commencement of processing of the Beaver Dam ore. Initially, process water is reclaimed from the TMF until pond volumes are depleted and inadequate to meet process water requirements. Reclaim is relocated and taken from the exhausted Touquoy pit as a closed loop. Additional freshwater may be required from Scraggy lake for start-up under dry conditions. Surplus water in the TMF is managed through the existing downstream discharge facilities and to the receiving environment at Scraggy Lake. Surplus water in the exhausted Touquoy pit is managed through a proposed spillway/conveyance channel to Moose River.

The water management plan should be updated to reflect the next stage of design. The Touquoy Closure plan should be updated to reflect the Beaver Dam tailings deposition and the resultant accelerated filling of the exhausted Touquoy pit and the changes to water quality. A water withdrawal approval from Scraggy Lake will be required from NSE for start-up process water supply.

7.2 TAILINGS DEPOSITION

It is assumed that tailings deposition will be performed using subaqueous deposition of a conventional tailings slurry through a barge. Deposition strategies will require routine modification based on the season. An approximate volume of deposited tailings of 6.03 Mm^3 is required for processing of Beaver Dam ore, including the pore water lockup. The capacity of the exhausted Touquoy pit can manage both the tailings and water volume, accommodating flood storage and freeboard.

The tailings management plan should be updated to reflect the next stage of design. A tailings deposition plan should be developed to support operation to define the monthly deposition areas.

7.3 WATER BALANCE MODEL

The water balance model provides an understanding of the water and tailings management for processing of the Beaver Dam ore.

The exhausted Touquoy pit in combination with the TMF is predicted to have sufficient process water for the Beaver Dam mine life. However, additional process water may be required from Scraggy Lake for start-up under dry climate conditions. The source of process water reclaim is triggered by the water elevation in the exhausted Touquoy pit, as a water management strategy. For example, initially process water will be reclaimed to the mill from the TMF through the existing reclaim barge and related water piping infrastructure until pond volumes are no longer adequate for process water reclaim. In approximately 5 months, process water will be reclaimed from the exhausted Touquoy pit as a closed loop between the pit and mill. Reclaiming process water initially from the TMF will reduce the required capacity of booster pumps in the exhausted Touquoy pit, as a greater capacity is required with depth. The existing reclaim water lines and decant pump could be retrofitted to accommodate the change to the source of the process water reclaim supply.

The water balance should be updated to reflect the next stage of design.

7.4 WATER QUALITY MODEL

Water quality modelling considered the pore water quality in the tailings and the pit floor and walls, dilution from surface runoff, direct precipitation in the pit, and the water quality of the mixture based on the geochemistry of the individual water quality parameters. Water quality is simulated to include elevated metals (e.g., arsenic, cobalt, copper), ammonia, nitrate and cyanide concentrations thus reducing pit lake water quality at the time of pit overflow discharge. The pit lake will be treated to meet applicable MDMER discharge limits for an existing mine prior to discharge to Moose River. As the pit lake was simulated to take approximately 14 years to fill from commencement of Beaver Dam ore, the water treatment design will be fully developed during operation and pit filling.

Water quality predictions and assimilative capacity in Moose River should be updated following an update of source terms as a result of the on-going Beaver Dam geochemistry assessment. Following this study, a water treatment plan should be further developed for implementation in operation and reclamation of Beaver Dam project.

8.0 REFERENCES

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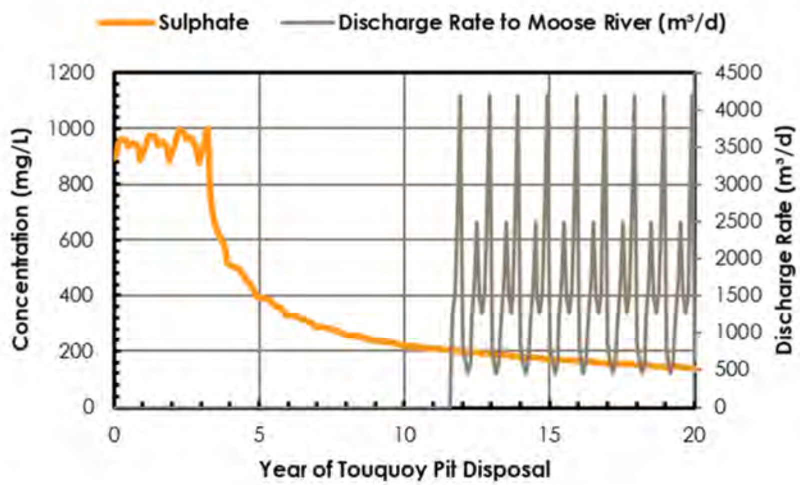
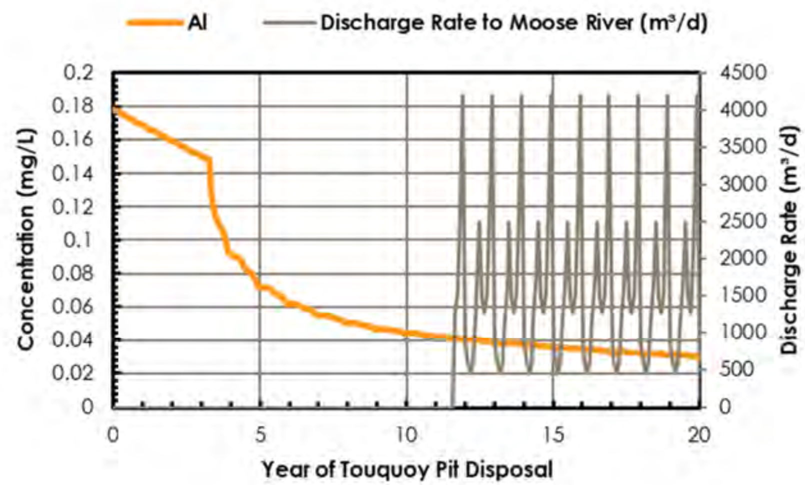
APPENDIX A

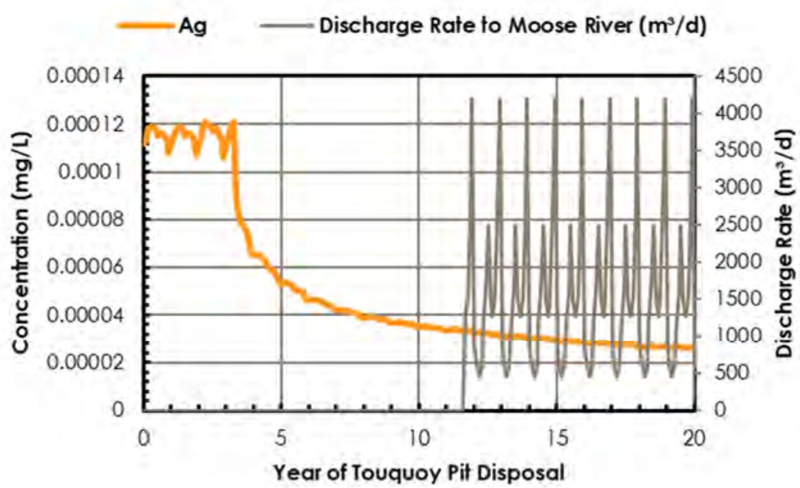
Water Quality Predictions



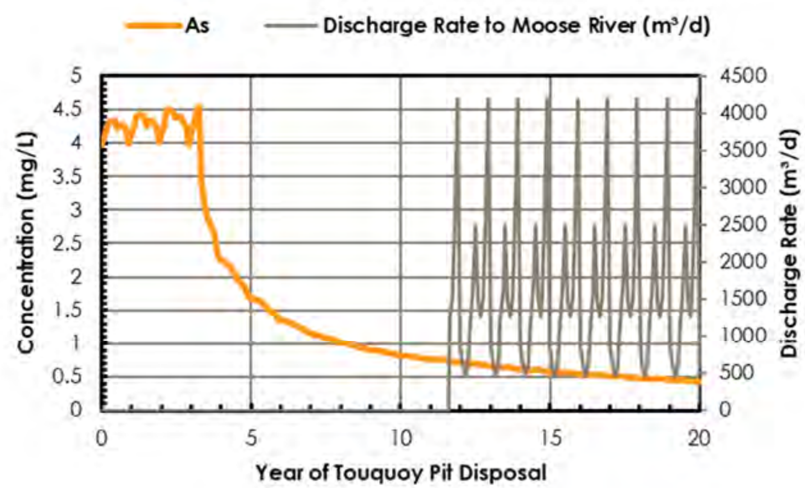
Sulphate
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



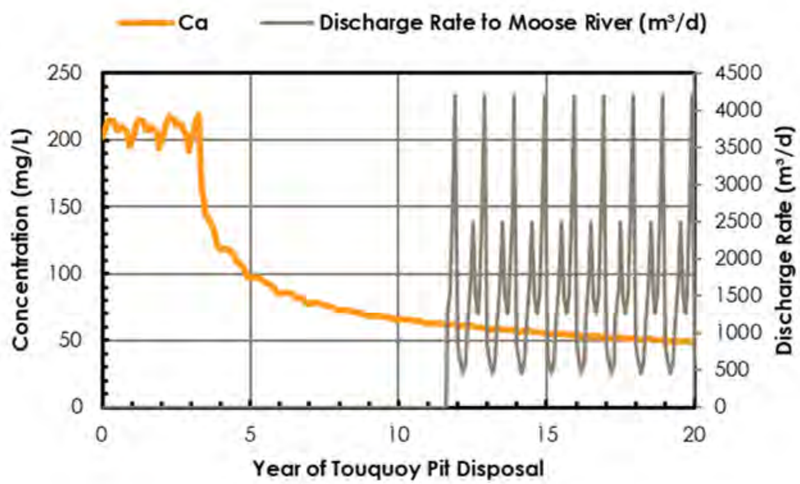
Al
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



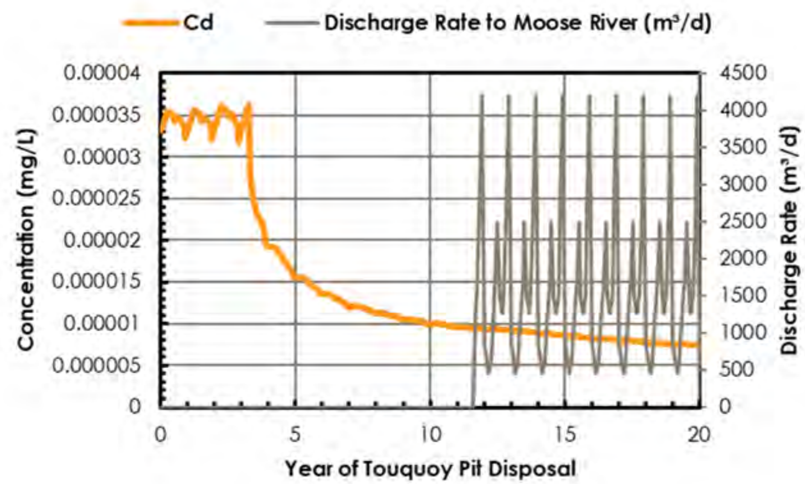
Ag
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



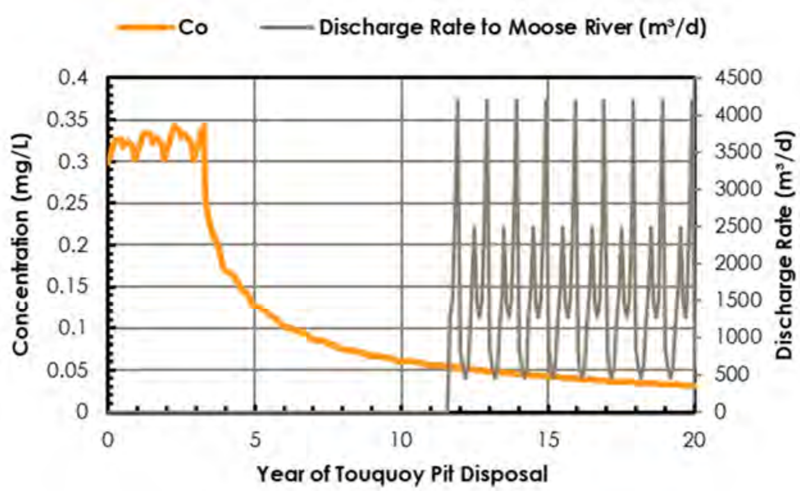
As
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



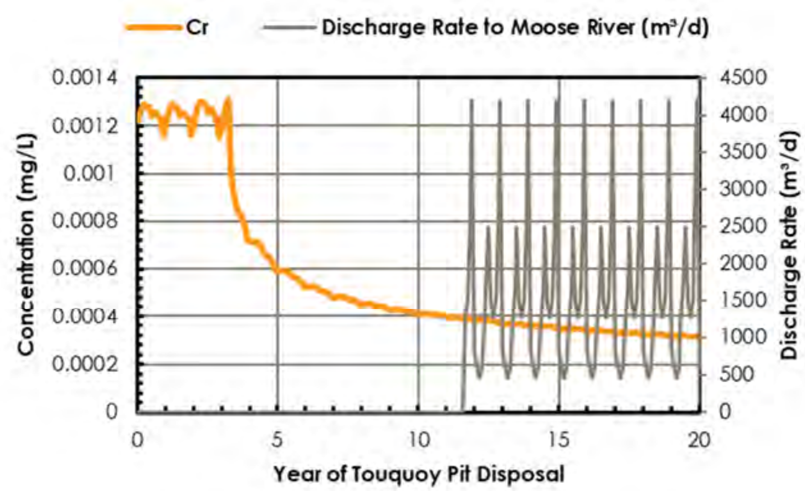
Ca
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



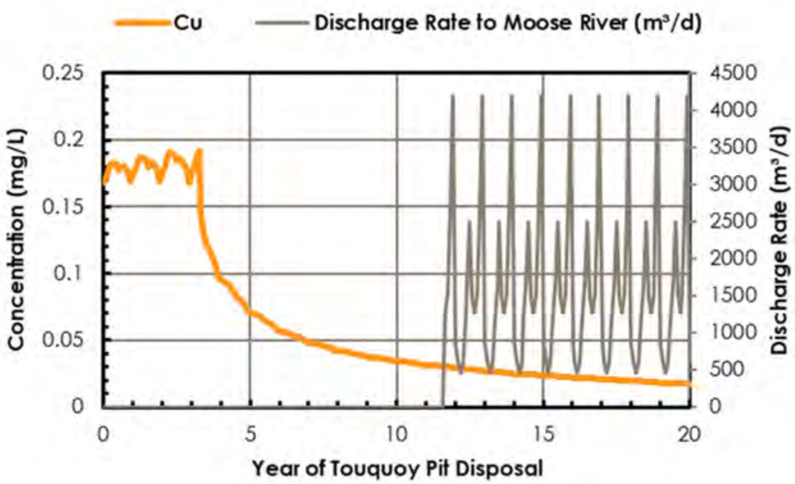
Cd
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal

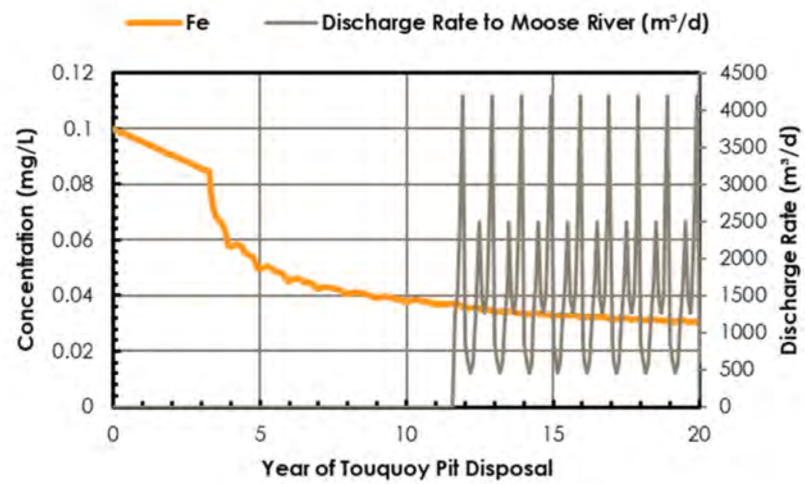


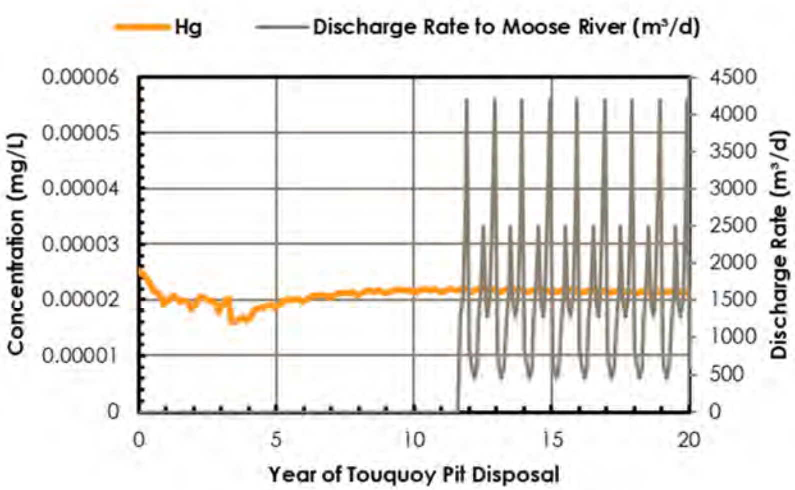
Co
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal

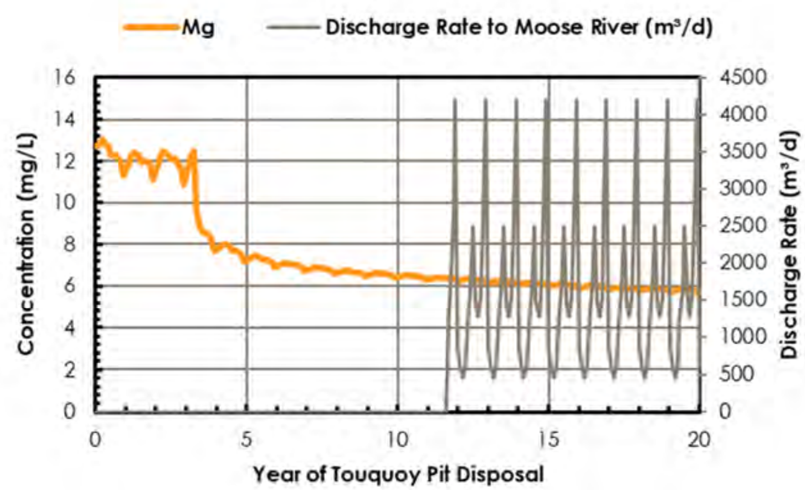


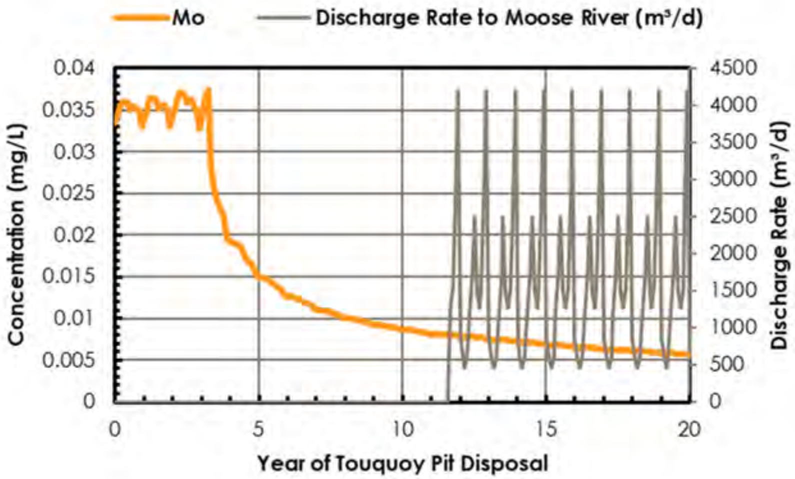
Cr
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal


Cu
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal

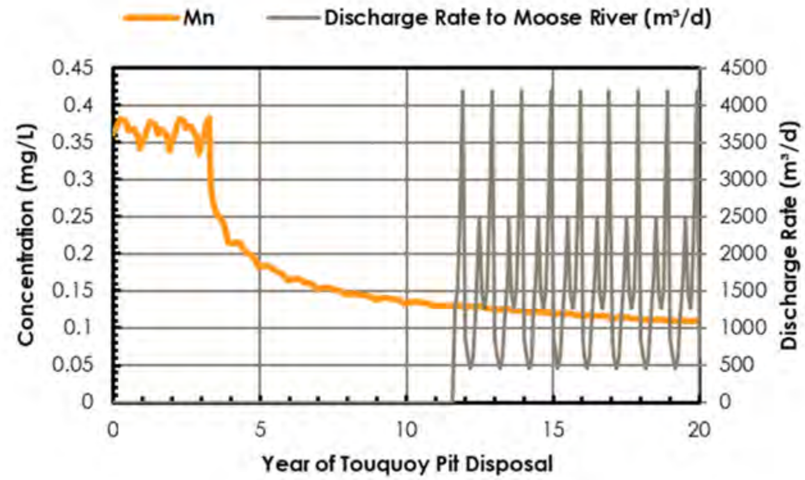

Fe
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal


Hg
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal

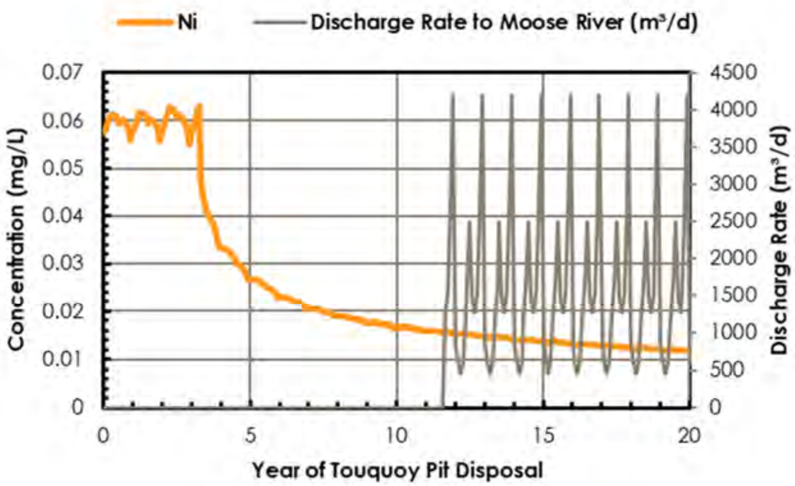

Mg
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



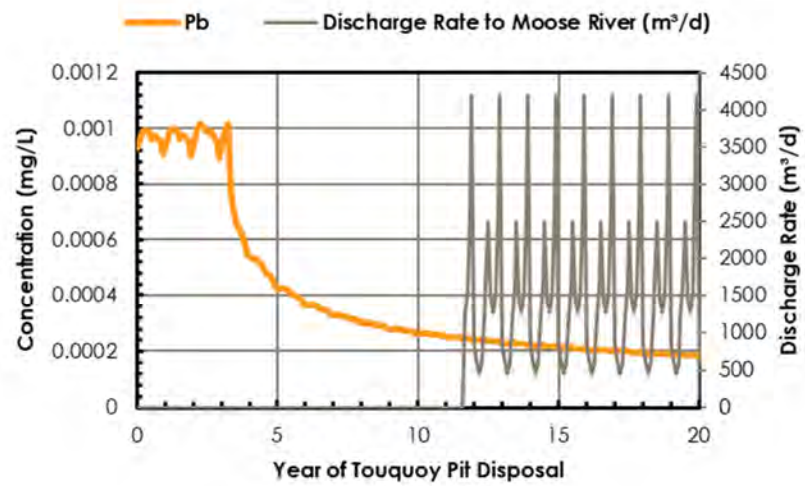
Mo
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
Discharge Rate (m³/d)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20
Year of Touquoy Pit Disposal



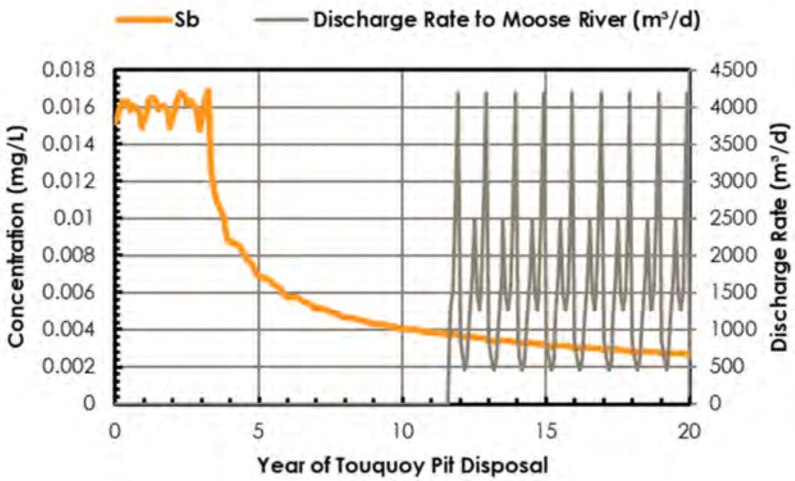
Mn
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Discharge Rate (m³/d)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20
Year of Touquoy Pit Disposal

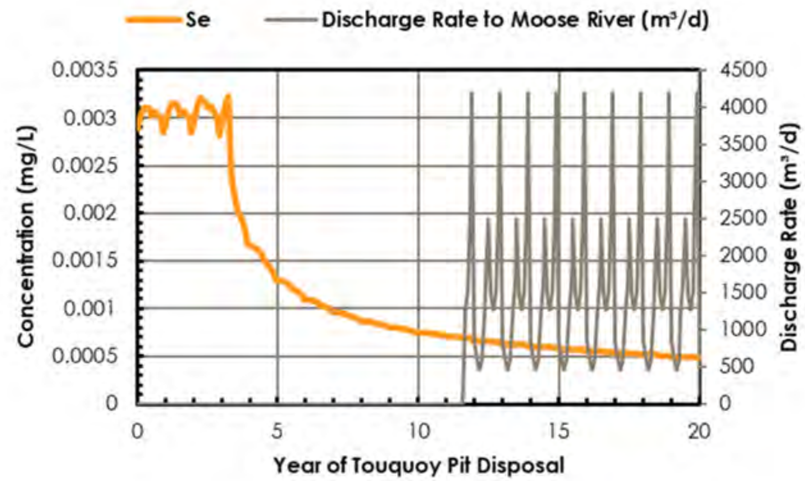


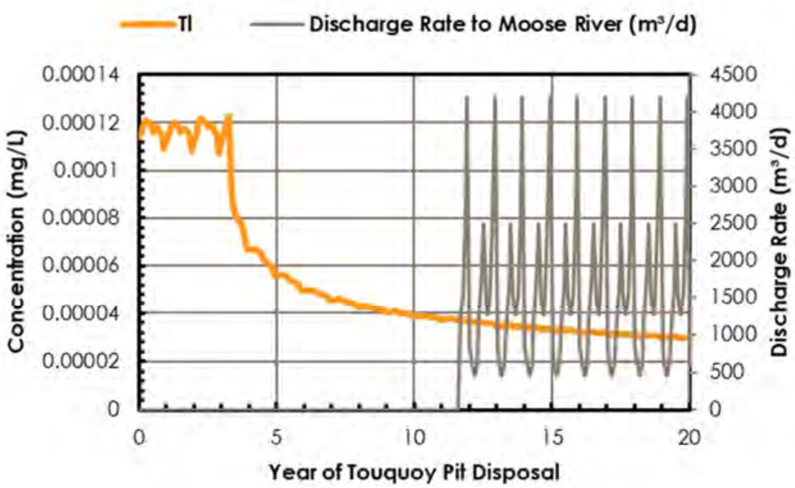
Ni
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
Discharge Rate (m³/d)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20
Year of Touquoy Pit Disposal

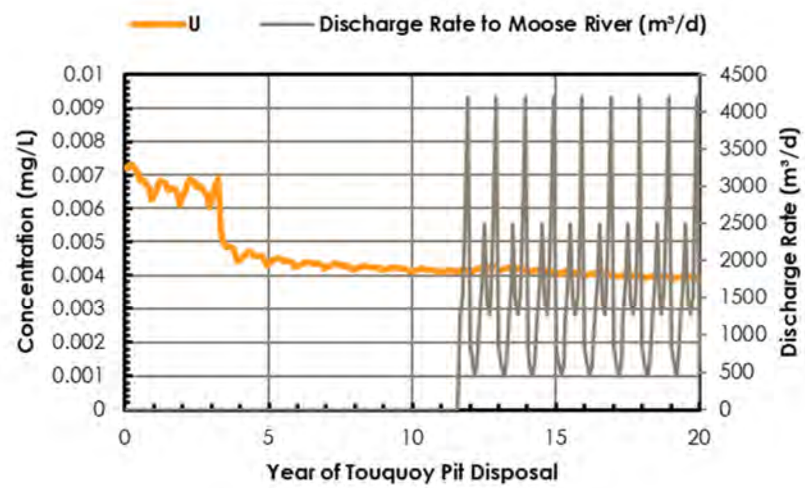


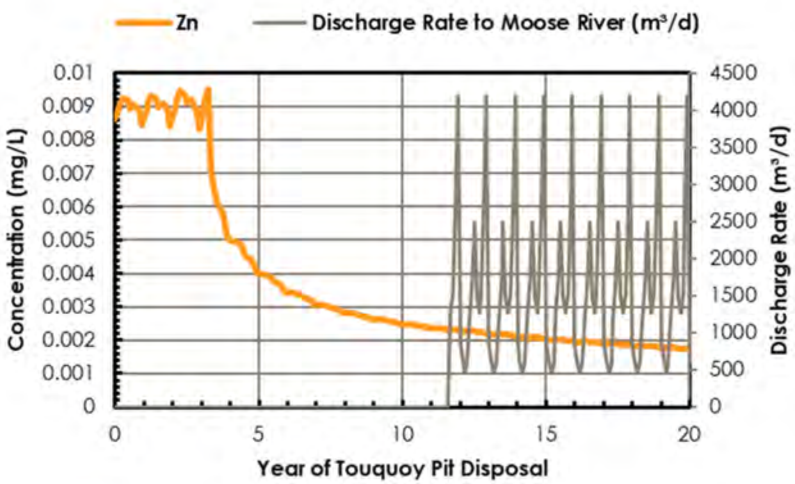
Pb
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
0
0.0002
0.0004
0.0006
0.0008
0.001
0.0012
Discharge Rate (m³/d)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
5
10
15
20
Year of Touquoy Pit Disposal


Sb
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
0.018 0.016 0.014 0.012 0.01 0.008 0.006 0.004 0.002 0
4500 4000 3500 3000 2500 2000 1500 1000 500 0
0 5 10 15 20
Year of Touquoy Pit Disposal

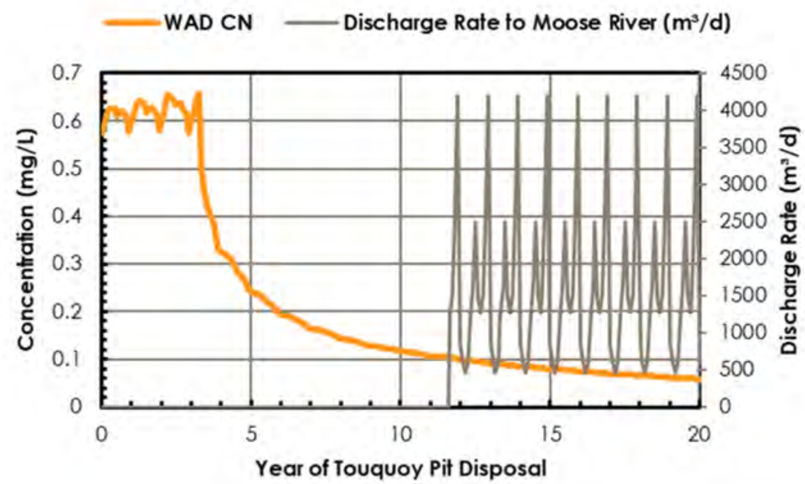

Se
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
0.0035 0.003 0.0025 0.002 0.0015 0.001 0.0005 0
4500 4000 3500 3000 2500 2000 1500 1000 500 0
0 5 10 15 20
Year of Touquoy Pit Disposal


Tl
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
0.00014 0.00012 0.0001 0.00008 0.00006 0.00004 0.00002 0
4500 4000 3500 3000 2500 2000 1500 1000 500 0
0 5 10 15 20
Year of Touquoy Pit Disposal

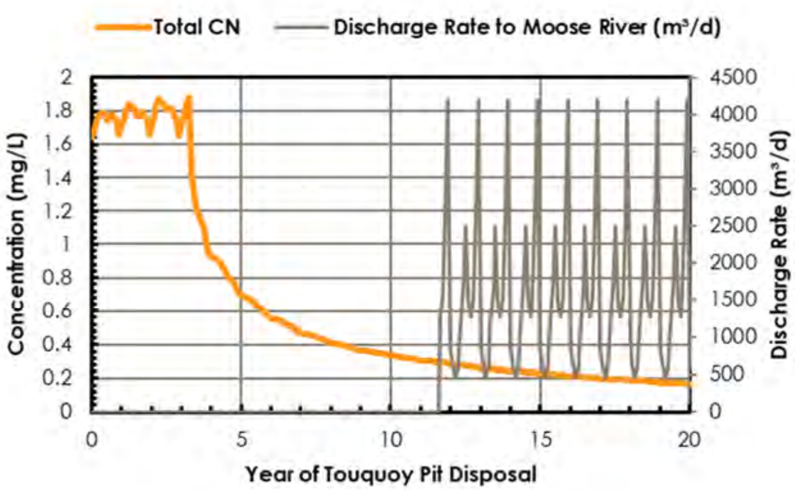

U
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
0.01 0.009 0.008 0.007 0.006 0.005 0.004 0.003 0.002 0.001 0
4500 4000 3500 3000 2500 2000 1500 1000 500 0
0 5 10 15 20
Year of Touquoy Pit Disposal



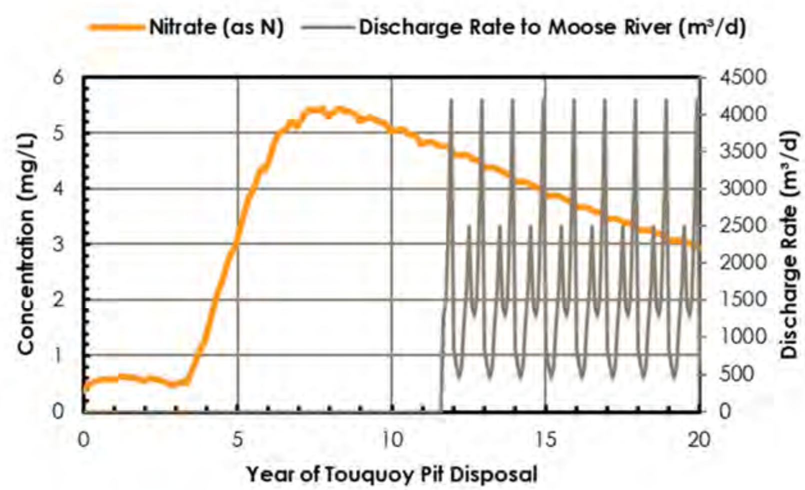
Zn
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20



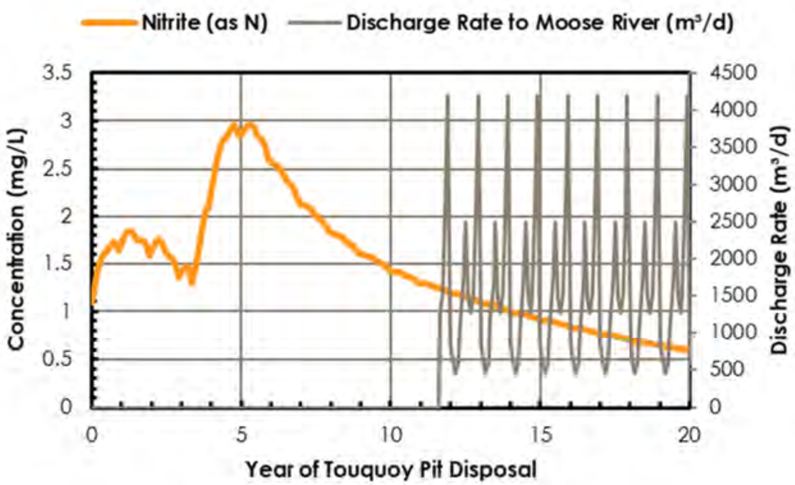
WAD CN
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20



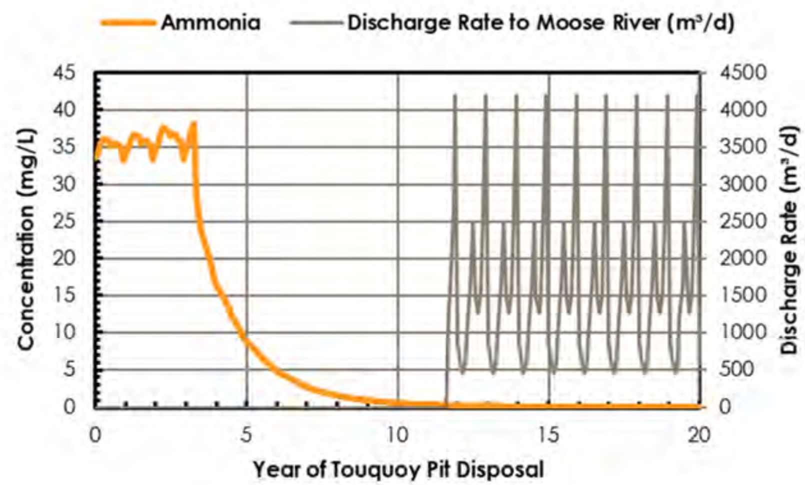
Total CN
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20



Nitrate (as N)
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal
6
5
4
3
2
1
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20



Nitrite (as N)
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal



Ammonia
Discharge Rate to Moose River (m³/d)
Concentration (mg/L)
Discharge Rate (m³/d)
Year of Touquoy Pit Disposal